...NTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS

PROCEEDINGS OF THE PUBLIC HEARINGS

OCTOBER, 1972

PART III

ENVIRONMENT CONSERVATION AUTHORITY

ALBERTA

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS

PROCEEDINGS OF THE PUBLIC HEARINGS

OCTOBER, 1972

PART III

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

TABLE OF CONTENTS

VOLUME I

RED DEER

VOLUME II

CALGARY

VOLUME III

EDMONTON

SUPPLEMENTARY SUBMISSIONS TO THE AUTHORITY

GENERAL

CRITIQUES

APPENDICES

PUBLIC HEARINGS EDMONTON

OCTOBER, 1972

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

Institut
Français
du
Pétrole
North
American
Office

A PRESENTATION TO THE ENVIRONMENT
CONSERVATION AUTHORITY OF THE PROVINCE OF ALBERTA

ON THE SUBJECT OF

THE ENVIRONMENTAL EFFECTS OF THE
OPERATION OF SULPHUR EXTRACTION GAS PLANTS IN ALBERTA

BY

INSTITUT FRANCAIS DU PETROLE
NORTH AMERICAN OFFICE
90 PARK AVENUE
NEW YORK, N.Y. 10016
U.S.A.

PRESENT FOR I.F.P.

PIERRE BONNIFAY

and

JOHN W. ANDREWS

Presented by: P. Bonnifay

EDMONTON , OCTOBER 19,1972

EDMONTON , October 19,1972

Mister Chairman
Members of the Authority
Ladies and Gentlemen,

Following the presentation made in the hearing in Calgary on behalf of the French Petroleum Institute an article was written in a Newspaper which does not reflect accurately the conclusions presented. If it is convenient with the members of the Authority I would like to quote the first and the last paragraphs of the article in question :

" Sulfur Extraction gas plants in Alberta could acheive 99.5% recovery for a total of $40 MM a representation of IFP said Tuesday " + ..

" He (P.Bonnifay) suggested total expenditure in the Province for the IFP-1 would be $20 MM."

I would like now to read again Mr. Chairman the conclusion presented:

CONCLUSIONS

"It has been estimated by IFP that a plant investment expenditure of the order of magnitude of $20,000,000 is necessary to have a small number of applicable plants within the Province of Alberta meet existing conservation board guidelines , when the IFP-1 process is utilized to meet these guidelines. A plant investment of the order of magnitude of $140,000,000 is estimated to be needed to bring stack effluents of almost all the gas plants within the entire Province down to levels similar to those proposed by the US Environmental Protection Agency, when using the IFP-2 process to meet these lower limits."

Using the project cost concept rather than the plant investment it is very likely that the figures estimated above would become respectively 30 MM$ and 210 MM$.

To further clarify I would like to state that the estimate of total plant investment of 20 MM$ is based on bringing the minimum recovery in the bracket of 98 to 99% for 9 plants which most likely would have to install a Claus tail gas treatment in order to comply with conservation Board guidelines.

Finaly I would like to emphasize the fact that a great difference exist between "Plant investment " and "Project Cost" and that although the total plant investment is estimated at 20 MM$ the"project cost" for the 9 plants considered might represent for the owners a total expenditure of some 30MM$.

PUBLIC HEARINGS

ENVIRONMENTAL EFFECTS OF THE
OPERATION OF SULPHUR EXTRACTION
GAS PLANTS IN ALBERTA

Edmonton, Alberta
October 19, 1972

Submitted by: Mrs. L. Swift
S.T.O.P.
Save Tomorrow -
Oppose Pollution

I am presenting this brief as a member of S.T.O.P. (Save Tomorrow - Oppose Pollution), out of concern for the environment and concern for the residents in the areas of the sulphur extraction gas plants whose health and livelihood may be jeopardized by the emissions and effluents from these plants.

This concern is justified, based on the statement of Dr. E.L Tollefson of the University of Calgary who said, "There is probably an insufficient safety margin for human health requirements in present emission standards. The average maximum SO_2 concentration of .10 ppm in twenty-four hours under Alberta air standards appears realistic for crops but is barely adequate in relation to people."[1.]

.10 ppm sounds optimistic when considering that some plants are allowed to let 100 long tons of sulphur escape through the stacks per day. The government has in the past kept check to see that this level is not exceeded -- tests were run once a year and on a pre-set date! Even with this warning of the testing, emissions have more than once, at the same plant, been above 100 long tons per day. The SO_2 concentrations which could arise from this volume of emission, with certain topographic and meteorological conditons, could easily become toxic. We have no report of any action taken when emission standards were found to be too high.

The Energy Resources Conservation Board has set new guidelines for plant emissions of sulphur only which seem to have caused great outrage among some gas companies as it will necessitate spending large sums of money on new equipment. As one representative put it: "The industry is not prepared to commit large sums required for processes which are not fully tested or verified."[2.] We wonder why industry is

prepared to subject local residents to conditions whose safety is not fully tested or verified. Would these representatives accept responsibility for the injuries to health blamed on plant-induced conditions?

The structure of the guideline system should not cause complaints from industry, as the guideline makes allowances for plant size so that the economic impact will be equalized. The Board has also stated that it is prepared to consider exemptions from the guidelines in special circumstances. However, in view of the responsibility of all or us to the environment and especially to the ecosystems of our own areas, these exemptions should not be asked for or accepted.

Even the new standards asking for 98 - 99% efficiency in large plants still allows up to 40 long tons per day to be released. This is a large burden for an ecosystem to carry.

It is understood that "environmental control, not direct economic advantage is the driving force to achieve conversions closer to 100%. The inclusion of environmental quality maintenance into the cost/benefit equation obviously dictates that costs will have to be borne for the benefit of environmental protection."[3.] It should also be approached that "the fact that the cost/benefit relationship is not of the traditional kind ... is no reason for not using established methods for maximizing the environmental benefit from the additional costs incurred."[4.]

If the companies cannot appreciate these ideals then possibly a charge levied for the extent to which they use the environment to dilute and dispose of their wastes, would provide the direct cost advantage incentive necessary. THis charge could then be put into a fund to recompense the surrounding residents, at least for the economic losses which the presence of the gas plants have caused.

No doubt this would serve to improve goodwill between plant operators and nearby residents more effectively than the campaign of 'honest education' suggested by the chairman of the ERCB, Dr. G.W. Govier, for this purpose. The 'honest' information to be relayed -- "advances in technology, benefits to Alberta in the industry's achievements in resource conservation, the size of payrolls generated and the amount of taxes paid."[5.] This is, no doubt, information already known. We

doubt that residents are impressed by it. This information does not make the discomfort, ill-health, loss of livestock, damage to crops and property , and for some families having to leave their homes, any easier to bear.

Since plant operations began, residents have complained to both industry and government with very poor results. They have been told "not to worry", yet there is no question in their minds that it is the emissions from the plants which have caused their children to suffer sore eyes, caused men to collapse in their fields and be hospitalized, and has resulted in chronic flu-like ailments to residents. Nor do they doubt that the plant emissions were a major contributing factor in the deaths of some elderly residents, or that these emissions contaminated their cattle and animals.

The complaints sound very extreme, yet they did not seem to shock or unduly concern the government. The government has carried out token air and water pollution surveys, as have gas companies with results showing no cause for alarm. This is not surprising, however, as the manner in which surveys were carried out would appear to be very careless. The surveys tested for an inadequate number of possible contaminants. There were an inadequate number of tests and the testing was neither consistent nor thorough. In addition, no allowance was made for variance according to topographic or meteorological conditions. Therfore, the conclusions which can be made, rather than "no cause for alarm", are either that illness is being caused by contaminants for which tests were not run, or that surveying monitors failed to record representative and accurate levels of concentration.

The inconclusiveness of these surveys did not prompt any further investigation or comprehensive research to find out what was causing the problems. However, one would expect that if the health of the residents had been considered important enough by the government, additional studies would have been conducted.

Ranchers in some areas have conducted their own research at their own expense, in an attempt to protect the health of their families. They have, however, neither the facilities nor the expertise in testing procedures to carry out a comprehensive investigation in this area.

The lack of governmental response and concern over this issue is alarming. The entire question of pollutants emitted by sulphur extraction plants goes far beyond our provincial handling of these problems. All over the world man is burdening the environment with sulphur compounds which pollute the soil, cause acid runoff into the already polluted creeks and rivers, and eventually reaches the oceans along with the other industrial and human wastes.

We cannot expect the oceans to survive the carelessness and lack of concern of nations such as ours much longer. The dangers to our oceans are very real. While we cannot expect the Province of Alberta to take responsibility for other nations or provinces, we can justly expect our province to maintain and set standards of safety within its own jurisdiction, and to urge the federal government and indeed other nations of the world, to maintain and set similar standards to protect the health of all citizens.

Although industry provides benefits for us all, the costs to the citizen or the environment must not exceed the value of industry's contribution. It is the function of government to protect the rights of industry, but it is primarily the function of the government to protect the health and welfare of all its citizens. After reviewing the information regarding the emissions from sulphur extraction plants, S.T.O.P. is forced to recommend to the provincial government that a more objective appraisal of this situation is in order.

S.T.O.P. further recommends that material from the Workmen's Compensation Board be more available to the public. Several reports have been made in confidence to S.T.O.P. regarding in-plant safety which has been described as poor. There have been accidents and it is impossible for the public to know whether the safety standards are adequate or not. Since public money pays for the compensation, the public should have the right to determine how injurious to health any particular job is.

S.T.O.P. would hope that all information given by employees at these hearings or received by any government agency regarding any aspect of the operation of sulphur extraction gas plants in Alberta, would be accepted with the understanding that no disciplinary action of any kind would be taken by the companies involved.

FOOTNOTES

1. Oilweek, June 19, 1972, "Operators face stiff imposition of Alberta sulphur guidelines." by Les Rowland, p. 31.

2. Ibid., p. 28.

3. Desulfurisation of Effluent Gas Streams - Review & Comparison of Techniques, J.B. Hyne, of the Fundamental Sulphur Research Group, p. 1.

4. Ibid., p. 25.

5. Ibid., see #1, p. 26.

ADDITIONAL REFERENCE

Environmental Pollution in the Drywood Creek Region of Southern Alberta, A brief submitted to the Department of the Environment, Department of Geography, University of Alberta.

QUESTIONING BY THE AUTHORITY

DR. W.R. TROST

You had asked that the Provincial Government take a more objective appraisal of this situation. Do you wish to structure that recommendation any more?

MRS. L. SWIFT

Well, more testing should be done. As Roger Klemm mentioned, testing for all different kinds of pollutants has not been done. Perhaps it should.

GREAT CANADIAN OIL SANDS LIMITED

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS WITH PARTICULAR REFERENCE TO GREAT CANADIAN OIL SANDS LIMITED OPERATION AT FORT MCMURRAY, ALBERTA

BY

GREAT CANADIAN OIL SANDS LIMITED

Presented by: F. A. Bain

SUBMITTED TO
ENVIRONMENT CONSERVATION AUTHORITY
EDMONTON, ALBERTA

OCTOBER 19, 1972

TABLE OF CONTENTS

PART I

INTRODUCTION

1.1 ALBERTA'S RESOURCES OF FOSSIL FUEL

ALBERTA HAS VAST RESERVES OF FOSSIL FUEL ENERGY FORMS - CRUDE OIL, GASEOUS HYDROCARBONS, TAR SANDS AND COAL.

THE TOTAL FOSSIL FUEL RESERVES ARE GENERALLY UNDERSTOOD TO BE EQUIVALENT TO BE APPROXIMATELY 3 X 10^{18} BTU'S OF ENERGY - DISTRIBUTED AS FOLLOWS:

		PERCENT SULPHUR
COAL	- 30.2% OF TOTAL	.2 - .6
CONVENTIONAL CRUDE OIL	- 5.8% OF TOTAL	0.56
GASEOUS HYDROCARBONS	- 5.8% OF TOTAL	0 - 50+
TAR SANDS (BITUMEN)	- 58.2% OF TOTAL	4.5
SYNTHETIC CRUDE	-	0.25

USE OF THE EXTENSIVE RESOURCES OF ALBERTA COAL HAS BEEN RESTRICTED BY THE HIGH COST OF TRANSPORTATION. THE SULPHUR CONTENT OF MUCH OF THE COAL IS EXCELLENT.

CRUDE OIL CONTAINS SULPHUR COMPOUNDS WHICH ARE SHIPPED WITH THE CRUDE. THE HEAVIER FUELS PRODUCED FROM THESE CRUDES GENERALLY CONTAIN MUCH OF THE SULPHUR OF THE ORIGINAL CRUDE AND RELEASE THIS SULPHUR AS SULPHUR DIOXIDE WHEN BURNED.

MUCH OF ALBERTA'S GAS CONTAINS SIGNIFICANT QUANTITIES OF SULPHUR COMPOUNDS WHICH MUST BE REMOVED BEFORE THE GAS IS SHIPPED TO ITS DESTINATION. GAS, AS SHIPPED, PRODUCES NO SO_2 IN THE DISTANT LOCATION WHERE IT IS FINALLY PURCHASED AND CONSUMED.

TAR SANDS BITUMEN IS HIGH IN SULPHUR AND REQUIRES EXTENSIVE REFINING.

SYNTHETIC CRUDE PRODUCED FROM TAR SANDS BITUMEN CONTAINS VERY LITTLE SULPHUR AND LIKE GAS, IS A CLEAN FUEL.

1.1.1 <u>THE ATHABASCA TAR SANDS DEPOSIT</u>

<u>LOCATION AND SIZE</u>

THE ATHABASCA TAR SANDS DEPOSIT COVERS A WIDE AREA ABOUT 250 MILES NORTH OF EDMONTON.

IT IS ESTIMATED THAT THE TAR SANDS UNDERLIE AN AREA OF SOME 30,000 SQUARE MILES.

EXCEPT FOR THE TOWN OF FORT MCMURRAY, THERE ARE FEW INHABITANTS IN THE ENTIRE AREA.

1.1.1.1 <u>ESTIMATE OF RESERVES</u>

THE ESTIMATED AMOUNT OF OIL IN THE ATHABASCA DEPOSIT IS ABOUT 600 BILLION BARRELS. OIL MEN AGREE THAT, WITH THE EXCEPTION OF SHALE OIL, THE ACCUMULATION IS THE GREATEST KNOWN ANYWHERE ON EARTH.

A GENERALLY ACCEPTED FIGURE OF 300 BILLION BARRELS OF PHYSICALLY RECOVERABLE OIL WAS GIVEN STATURE LATE IN 1963 BY THE ALBERTA OIL AND GAS CONSERVATION BOARD.

THE IMMENSITY OF THIS QUANTITY IS SHOWN BY THE FACT THAT IT IS ENOUGH TO SUPPLY THE ENTIRE NORTH AMERICAN CONTINENT FOR MORE THAN 60 YEARS ON THE BASIS OF TODAY'S DEMAND FOR OIL.

1.2 HISTORY OF ALBERTA TAR SANDS

THE ATHABASCA TAR SANDS ARE A HUGE DEPOSIT OF QUARTZ SAND AND CLAY IMPREGNATED WITH HEAVY OIL OR BITUMEN, LOCATED IN THE ATHABASCA RIVER REGION OF NORTHEASTERN ALBERTA.

THE DEPOSIT, CONTAINED IN THE LOWER CRETACEOUS MCMURRAY FORMATION, RANGES IN THICKNESS FROM A FEW FEET TO MORE THAN 150 FEET. IT RESTS ON A HARD LIMESTONE FORMATION THAT TILTS UPWARD FROM SOUTHWEST TO NORTHEAST.

IN THE VICINITY OF THE TOWN OF FORT MCMURRAY, AT THE JUNCTION OF THE ATHABASCA AND CLEARWATER RIVERS, THE TAR SANDS ARE IN MANY PLACES EXPOSED ON THE SURFACE.

SUCH OVERBURDEN AS EXISTS IN THIS AREA IS THIN AND IS COMPOSED OF GLACIAL SANDS, GRAVEL AND BOULDERS. IN OTHER AREAS, THE OVERBURDEN IS UP TO 1,000 FEET THICK.

EXISTENCE OF THE TAR SANDS WAS FIRST RECORDED BY PETER POND, ADVENTURER, FUR-TRADER AND EXPLORER IN 1778.

IT WAS ABOUT A CENTURY AFTER POND THAT THE GEOLOGICAL SURVEY OF CANADA, IN 1895, INSTITUTED PLANS FOR A SURVEY. VARIOUS TESTS THROUGH THE YEARS PROVED MORE AND MORE OIL IN PLACE, BUT IT'S THICK, GUMMY NATURE LED GENERALLY TOWARD EXPERIMENTS IN USING IT AS A PAVING MATERIAL.

1.2.1 EXPERIMENTS IN SEPARATION

EFFORTS TO SOLVE THE PUZZLE OF SEPARATING THE OIL FROM THE SAND STARTED MANY YEARS AGO. AS EARLY AS 1919, WHEN THE ALBERTA RESEARCH COUNCIL WAS FORMED AS AN ARM OF THE PROVINCIAL GOVERNMENT, STEPS ALREADY HAD BEEN TAKEN TO FIND A PRACTICAL SEPARATION METHOD.

UNDERGROUND BURNING WAS TRIED AS EARLY AS 1929. VARIOUS OTHER APPROACHES TO IN SITU (IN PLACE) SEPARATION WERE CONSIDERED BY LATER EXPERIMENTERS, INCLUDING ATOMIC BLASTS.

THE EARLY TEST PLANTS USED VARIOUS HOT WATER SEPARATION PROCESSES. AMONG THEM WAS A SEPARATION PLANT AND REFINERY NEAR FORT MCMURRAY BUILT BY ABASAND OILS LTD., UNDER THE LEADERSHIP OF THE LATE MAX. W. BALL; AND INTERNATIONAL BITUMEN COMPANY LIMITED AT BITUMOUNT, ABOUT 50 MILES NORTH OF FORT MCMURRAY BUILT BY R.C. FITZSIMMONS.

INTERNATIONAL BITUMEN COMPANY WAS ACQUIRED IN 1942 BY L.R. CHAMPION, ORGANIZER OF OIL SANDS LIMITED, WHICH IN COLLABORATION WITH THE ALBERTA GOVERNMENT, CONSTRUCTED A 500 TONS PER DAY CAPACITY PLANT AT BITUMOUNT.

THIS PLANT WAS TAKEN OVER BY THE ALBERTA GOVERNMENT BEFORE ITS COMPLETION. IT WAS OPERATED ON A TEST BASIS IN 1948 AND THEN CLOSED IN 1949.

1.3 GREAT CANADIAN OIL SANDS LTD. BACKGROUND

SUN OIL COMPANY'S INTEREST IN ATHABASCA TAR SANDS GOES BACK AT LEAST AS FAR AS 1944, WHEN THE LATE J. EDGAR PEW, THEN VICE - PRESIDENT IN CHARGE OF PRODUCTION

HAD DISCUSSIONS WITH L.R. CHAMPION OF OIL SANDS LTD.

TEN YEARS LATER, SUN PROVIDED FUNDS FOR TAR SANDS DEVELOPMENT IN RETURN FOR A 75 PERCENT INTEREST IN ABASAND OIL'S LEASE NO. 86 AT MILDRED-RUTH LAKES.

1.3.1 ORIGIN OF THE GREAT CANADIAN OIL SANDS LIMITED PROJECT

GREAT CANADIAN OIL SANDS LIMITED, INCORPORATED IN 1953, ACQUIRED OIL SANDS LTD., ITS PATENTS, STUDIES AND LEASE 14 AND THUS IS SUCCESSOR TO SOME OF THE EARLIEST PIONEERING WORK INTHE ATHABASCA REGION. IT REPRESENTS AN ACCUMULATION OF EXPERIENCE AND KNOW-HOW DATING FROM BEFORE 1930, INCLUDING THE PATENT ON THE HOT WATER PROCESS DEVELOPED BY R.C. FITZSIMMIONS, AS WELL AS THE WORK OF L.R. CHAMPION AND OIL SANDS LTD. IN COLLABORATION WITH THE ALBERTA GOVERNMENT.

WHILE BOTH THE FITZSIMMONS PROCESS AND THE PROCESS USED BY OIL SANDS LTD. EMPLOYED THE HOT WATER PRINCIPLE, THEY VARY IN APPLICATION. THE LATTER PROCESS FOLLOWED PROCEDURES DEVELOPED BY THE ALBERTA RESEARCH COUNCIL UNDER THE LEADERSHIP OF THE LATE DR. KARL A. CLARK WHO WAS A CONSULTANT TO GCOS UNTIL HIS DEATH IN DECEMBER 1966.

IN 1958, SUN AND CANADIAN OIL COMPANIES LTD., (NOW SHELL) CONTRACTED TO PURCHASE 75 AND 25 PERCENT, RESPECTIVELY, OF THE OUTPUT OF THE PROPOSED GCOS PLANT.

1.3.2 SCOPE OF PROJECT

IN 1960, GCOS MADE FORMAL APPLICATION TO THE ALBERTA OIL AND GAS CONSERVATION BOARD FOR A PERMIT TO UNDERTAKE A COMMERCIAL PROJECT WITH A CAPACITY OF 31,500 BARRELS PER DAY OF SYNTHETIC CRUDE FROM THE ATHABASCA TAR SANDS. HEARINGS

WERE HELD, AND IN NOVEMBER OF THAT YEAR THE BOARD RECOMMENDED TO THE ALBERTA GOVERNMENT THAT FURTHER CONSIDERATION OF THE GCOS APPLICATION BE DEFERRED UNTIL JUNE 1962.

HEARINGS IN MID-1962 ON THE GCOS REQUEST RESULTED IN APPROVAL BY THE BOARD IN SEPTEMBER AND BY THE GOVERNMENT OF ALBERTA ON OCTOBER 2ND, 1962. THUS GCOS BECAME THE FIRST COMPANY TO RECEIVE A PERMIT TO PRODUCE ON A MAJOR COMMERCIAL BASIS FROM THE GIANT ATHABASCA DEPOSIT.

IT WAS GIVEN UNTIL SEPTEMBER 30TH, 1963 TO COMPLETE FINANCING ARRANGEMENTS; UNTIL JANUARY 1ST, 1964, TO BEGIN CONSTRUCTION; AND UNTIL SEPTEMBER 30TH, 1966, TO START RECOVERY OPERATIONS.

AS A DEADLINE FOR FINANCING NEARED, GCOS ON SEPTEMBER 25TH, 1963, FILED AN APPLICATION FOR THESE AMENDMENTS: (A) CERTAIN PROCESS CHANGES; (B) AN EXTENSION OF TIME FOR FINANCING; AND (C) APPROVAL OF AN INCREASE IN VOLUME OF SYNTHETIC CRUDE RECOVERY FROM THE ORIGINALLY APPROVED 31,500 BARRELS PER DAY TO 45,000 BARRELS PER DAY.

THE APPLICATION WAS ACCOMPANIED BY A LETTER FROM SUN PRESIDENT, ROBERT G. DUNLOP TO GREAT CANADIAN, OUTLINING THESE AMENDMENTS AS CONDITIONS UNDER WHICH SUN WOULD INVEST UP TO $67,500,000 AND ASSIST IN ARRANGING THE ADDITIONAL FINANCING NECESSARY FOR THE $235,000,000 PROJECT.

THE BOARD EXTENDED THE TIME FOR GCOS TO COMPLETE ITS FINANCING AND SET NOVEMBER 26TH AS THE DATE FOR PUBLIC HEARINGS. IT ANNOUNCED ITS FAVOURABLE DECISION ON FEBRUARY 14TH, 1964 RECOMMENDING APPROVAL OF THE INCREASE AND

SETTING SEPTEMBER 1, 1964 AS THE DATE FOR START OF CONSTRUCTION AND SEPTEMBER 30TH, 1967, AS THE DEADLINE FOR START OF RECOVERY OPERATIONS. APPROVAL BY THE GOVERNMENT FOLLOWED ON APRIL 10TH, 1964.

1.3.3 FORT MCMURRAY HISTORY

IN 1870, FORT MCMURRAY WAS FOUNDED BY H.J. MOBERLY OF THE HUDSON'S BAY COMPANY WHO NAMED THE FORT AFTER J.D. MCMURRAY OF THE NORTH WEST COMPANY.

IN THE EARLY 1920'S THE ALBERTA AND GREAT WATERWAYS RAILROAD (NOW NORTHERN ALBERTA RAILWAYS) WAS BUILT TO WATERWAYS, SLIGHTLY SOUTHEAST OF MCMURRAY, AND ALL FREIGHT TO THE NORTH WAS TRANSFERRED FROM TRAINS TO BARGES AT WATERWAYS WHICH MADE IT A BUSTLING COMMUNITY DURING THE SUMMER MONTHS.

ON MAY 6TH, 1947, FORT MCMURRAY WAS INCORPORATED AS A VILLAGE; ON DECEMBER 29TH, 1948 IT WAS PROCLAIMED A TOWN AND IT RECEIVED THE "NEW TOWN STATUS" ON JANUARY 30TH, 1964. AT THIS TIME THE TOWN HAD A POPULATION OF JUST OVER 1300 AND THE MAIN COMMERCIAL ACTIVITY CENTRED AROUND THE RAILWAY TERMINAL AND TRANS-SHIPMENT TO NORTHERN TRANSPORTATION COMPANY BARGES.

THE GREAT CANADIAN OIL SANDS COMPANY PLANT HAS BEEN INSTRUMENTAL IN THE EXPANSION OF THE TOWN OF FORT MCMURRAY INTO A MODEL COMMUNITY OF OVER 7,000 POPULATION, WITH MODERN SHOPPING CENTRES, SCHOOLS, PAVED STREETS, UNDERGROUND WIRING AND GAS. THE TOWN'S TEN MILLION DOLLAR ANNUAL PAYROLL IS THE ENVY OF MANY OTHER SMALL BUSINESS TOWNS IN ALBERTA.

1.3.4 PERMIT, APPROVAL, ENGINEERING & CONSTRUCTION

CANADIAN BECHTEL LIMITED, DESIGNED, ENGINEERED, AND CONSTRUCTED THE HUGE PROJECT.

TECHNICAL AND FEASIBILITY STUDIES COMMENCED SHORTLY AFTER GREAT CANADIAN OIL SANDS RECEIVED THE ORIGINAL PERMIT IN THE FALL OF 1962. THIS WORK, WHICH LED TO THE AMENDED PERMIT IN EARLY 1964, ESTABLISHED THE BASIC CONCEPTS OF THE DESIGN. DETAILED FINAL DESIGN WORK WAS THEN COMMENCED AND WAS ESSENTIALLY COMPLETED IN THE FALL OF 1966. DURING THAT PERIOD, APPROXIMATELY 850,000 TECHNICAL MAN HOURS WERE EXPENDED BY THE ENGINEER CONTRACTOR CANADIAN BECHTEL LIMITED, IN VARIOUS OFFICES IN CANADA AND THE UNITED STATES.

FIELD WORK STARTED IN THE SPRING OF 1964 WITH THE CONSTRUCTION OF A BRIDGE AND ROAD TO PROVIDE ACCESS FROM FORT MCMURRAY TO THE SITE FOR MEN AND MATERIALS. DURING CONSTRUCTION, APPROXIMATELY 8.7 MILLION MAN HOURS WERE EXPENDED IN THE FIELD. THE NUMBER OF MEN EMPLOYED REACHED 2,200. BY JULY 1967, THE PLANT WAS MECHANICALLY COMPLETE AND TESTING WAS UNDERWAY. THE PROJECT WAS COMPLETED ON SCHEDULE IN FULL COOPERATION WITH GOVERNMENT AUTHORITIES AND THE PERMIT CONDITIONS.

THE FINAL AIR POLLUTION CONTROL PERMIT 365-0-508 WAS ISSUED MAY 25TH, 1967. THE PERMIT REQUIRES THAT THE SULPHUR PLANT DESIGN LIMIT SULPHUR EMISSIONS TO 22.5LTS/DAY AT AN EMISSION TEMPERATURE OF NOT LESS THAN 1000^{O}F. FROM 350' INCINERATOR STOCK. IT ALSO REQUIRES THAT WHEN EMISSION OF HYDROGEN SULPHIDE IS UNAVOIDABLE IT SHALL BE CONSUMED IN A 250 FOOT DISPERSION STACK WITH A QUANTITY OF FUEL GAS EQUAL TO TWICE THE THERMAL CONTENT OF THE HYDROGEN SULPHIDE. THE

INSTALLATION AND LOCATION OF 20 HYDROGEN SULFIDE AND TOTAL SULFATION ABSORPTION STATIONS AND TWO CONTINUOUS HYDROGEN SULFIDE AND SULPHUR DIOXIDE MONITORS AND MONTHLY SUBMISSION OF REPORTS IS SPELLED OUT. TWO SURVEYS AND COMPLETE ANALYSIS OF THE INCINERATOR STACK GAS ARE REQUIRED ANNUALLY. TWELVE DUSTFALL CYLINDERS HAVE ALSO BEEN INSTALLED IN PRESCRIBED LOCATIONS TO MONITOR FREE SULPHUR FALLOUT IN THE AREA.

1.3.5 GREAT CANADIAN OIL SANDS AS A CORPORATE CITIZEN

OPERATING LOSSES HAVE BEEN INCURRED EACH YEAR SINCE 1967 DUE TO DIFFICULTIES IN REACHING PRODUCTION LEVELS AND TO INCREASED COSTS. IMPROVEMENTS TO THE PLANT AND CONTINUOUS EFFORTS BY MANAGEMENT AND STAFF HAVE REDUCED THESE ANNUAL LOSSES BUT TO DATE THEY EXCEED $80,000,000.

GCOS WAS FORTUNATE TO HAVE THE PATIENCE, PERSEVERANCE FAITH AND RESOURCES OF SUN OIL COMPANY BEHIND IT AND THAT IS THE ONLY REASON GCOS IS ALIVE TODAY AND IMPROVING IN HEALTH.

SUN'S ORIGINAL COMMITMENT OF $67.5 MILLION HAS BURGEONED TO NEARLY $300 MILLION. SUN OIL IN 1969 PURCHASED $100 MILLION IN PREFERRED SHARES OVER AND ABOVE THE FINANCING CONTEMPLATED IN THE $67.5 MILLION. THIS WAS FOLLOWED IN 1970 BY YET ANOTHER $100 MILLION IN EXCHANGE FOR COMMON SHARES. A FURTHER $20 MILLION AUGMENTED THESE FUNDS IN 1971 IN EXCHANGE FOR PREFERRED SHARES.

SUN OF COURSE, DID NOT HAVE TO PUT THESE EXTRA FUNDS TOTALLING $220 MILLION INTO GCOS. IT COULD HAVE ALLOWED THE PROJECT TO DIE ON THE VINE, WRITTEN OFF ITS LOSSES AND PROCEEDED TO PUT ITS FUNDS INTO ANY NUMBER OF OTHER INVESTMENT OPPORTUNITIES AROUND THE WORLD. IT CHOSE TO STICK WITH THE GCOS PROJECT FOR A NUMBER OF REASONS.

FIRST, IT COULD SEE THAT SOME OF THE DIFFICULTIES WERE SLOWLY BUT STEADILY BEING RESOLVED AND THE POSSIBILITY EXISTED FOR A VIABLE OPERATION AT FORT MCMURRAY.

SECOND, IT WAS BECOMING INCREASINGLY APPARENT THAT NORTH AMERICA WAS GOING TO NEED A PETROLEUM RESOURCE SUCH AS THE ATHABASCA OIL SANDS. THE EASILY ACCESSIBLE CONVENTIONAL OIL SOURCES WERE BECOMING MORE DIFFICULT AND CONSEQUENTLY MORE EXPENSIVE TO FIND. FURTHER, DEMAND WAS ACCELERATING RAPIDLY, NOT ONLY IN NORTH AMERICA, BUT WORLD-WIDE. AS ANTICIPATED, THESE FACTORS HAVE NOW COMBINED TO FOCUS ATTENTION ON THE ATHABASCA OIL SANDS AS A POTENTIAL SOURCE OF HYDROCARBON ENERGY.

THE THIRD REASON RECOGNIZED THAT HUNDREDS OF GCOS EMPLOYEES AND THEIR FAMILIES HAD MADE A CAREER COMMITMENT TO OUR PROJECT AND TO OUR WAY OF THINKING, IT WAS VITAL THAT THESE PEOPLE BE GIVEN EVERY OPPORTUNITY TO FULFILL THAT COMMITMENT.

FOURTH, THE TOWN OF FORT MCMURRAY DEPENDS TO A GREAT EXTENT ON GCOS. IF THE PLANT HAD CLOSED, IT WOULD HAVE MEANT A SEVERE SETBACK FOR MANY TOWNSPEOPLE AND THE PROVINCE, AS WELL AS OUR OWN EMPLOYEES.

FINALLY, WE REALIZED THAT SHOULD THE GCOS PROJECT FAIL, THE DEVELOPMENT OF THE OIL SANDS COULD HAVE BEEN EXTENSIVELY DEFERRED OR PERHAPS ABANDONED. FUTURE DEVELOPERS WOULD HAVE FELT COMPELLED TO REASSESS THEIR CHANCES OF SUCCESS IN THE LIGHT OF OUR EXPERIENCE AND, AS A RESULT, COULD HAVE DECIDED TO TURN THEIR ATTENTION TO SOME OTHER NON-CONVENTIONAL SOURCE OF HYDROCARBON ENERGY.

GCOS AS A CORPORATE CITIZEN, BUILT THE ROAD FROM FORT MCMURRAY TO THE PLANT; SHARED IN THE COST OF CONSTRUCTION OF THE BRIDGE OVER THE ATHABASCA RIVER AT FORT MCMURRAY; CONTRIBUTES TO THE ALBERTA ECONOMY THROUGH TAXES AND ROYALTIES; CONTRIBUTES A GREAT DEAL TO THE COMMUNITY, THE PROVINCIAL, AND THE NATIONAL EFFORTS, BOTH TECHNICALLY AND SOCIALLY; MAKES SOME OF IT'S FINEST PEOPLE AVAILABLE FOR COMMUNITY LEADERSHIP AND CONTRIBUTES MONEY TO DIFFERENT COMMUNITY PROJECTS; REACTED PROMPTLY AND CONSCIENTIOUSLY IN COPING WITH THE HIGHLY ADVERTISED OIL SPILL IN 1970.

THE TASK OF PRODUCING CRUDE OIL, PROCESSING IT, AND DELIVERING IT IN USEABLE FORMS OF ENERGY TO MILLIONS OF PEOPLE IS BY NATURE FRAUGHT WITH POTENTIALITIES FOR INJURY TO THE ENVIRONMENT.

GCOS INVOLVMENT IN PRESERVING THE ENVIRONMENT IS NOT A RECENT DEVELOPMENT, NOR IS IT LIMITED IN SCOPE. IT REFLECTS A RECOGNITION OVER THE YEARS THAT NOT ONLY MUST THE COMPANY MEET THE TEST OF COMPETITION IN SERVING THE WANTS OF THOSE WHO ARE DEPENDENT UPON IT, BUT IT MUST AT THE SAME TIME EXERCISE GREAT CARE NOT TO DESPOIL THE AIR, LAND OR SEA.

GCOS APPEARS AT THIS HEARING BECAUSE WE HAVE A MAJOR INVESTMENT IN THE TAR SANDS PROJECT AND A MAJOR COMMITMENT TO THE PEOPLE INVOLVED. WE ARE PART OF THE COMMUNITY OF FORT MCMURRAY, WE RAISE OUR CHILDREN THERE AND THUS, ARE GENUINELY CONCERNED WITH THE QUALITY OF THE ENVIRONMENT.

ALTHOUGH THE PURPOSE OF THIS HEARING IT SPECIFICALLY RELATED TO SULPHUR EXTRACTION GAS PLANTS, THE RECOMMENDATIONS EMINATING FROM THE HEARING COULD HAVE A PROFOUND IMPACT ON OUR OWN SULPHUR RECOVERY FACILITIES. WE HAVE SPENT

CONSIDERABLE TIME LOOKING INTO THE EFFECT OF OUR SULPHUR PLANT ON THE SURROUNDING ENVIRONMENT, AND IN GENERAL HAVE FOUND ESSENTIALLY NO ADVERSE IMPACT RESULTING FROM IT'S OPERATION.

WE ARE FRANKLY CONCERNED THAT THE GOVERNMENT IS NOW PLANNING TO IMPOSE MORE SEVERE REGULATIONS ON SULPHUR RECOVERY OPERATIONS AND NEARLY ALL AVAILABLE EVIDENCE REFUTES THE NEED FOR TIGHTER CONTROLS. IS THE ECONOMIC BURDEN IMPOSED BY TIGHTER CONTROLS REALLY JUSTIFIED? HAVE THE SO_2 EMISSIONS FROM ALBERTA'S SULPHUR RECOVERY OPERATIONS HAD ANY APPRECIABLE ADVERSE IMPACT ON THE ENVIRONMENT? WE THINK THE ANSWER IS NO.

THROUGH OUR TESTIMONY, WE HOPE TO RE-EMPHASIZE TO THE ECA THAT THERE MUST BE PROPER BALANCE BETWEEN INDUSTRY AND ENVIRONMENT. PRESENTLY, AMBIENT AIR QUALITY REGULATIONS, AS WE WILL DESCRIBE LATER, ARE MORE THAN ADEQUATE TO PROTECT OUR ENVIRONMENT. WITH SOME MINOR EXCEPTIONS, OR DURING UPSETS, THE SULPHUR PLANT OPERATORS MEET THESE VERY STRICT STANDARDS.

PART 2

ALBERTA GAS PLANTS AND SULPHUR ENVIRONMENTAL REGULATIONS

2.1 HISTORY OF ALBERTA GAS PLANTS

TURNER VALLEY HOLDS A FIRM AND MONUMENTAL PLACE IN ALBERTA HISTORY AND LEGEND AS THE SITE OF WHAT WAS HOPED WOULD BE THE JUMPING OFF POINT FOR ALBERTA'S ECONOMY. THE TURNER VALLEY FIELD HAD ALREADY BEEN DELINEATED IN 1914. HOWEVER, IT WASN'T UNTIL 1924 THAT ROYALITE NO.4 PENETRATED THE MAIN RESERVOIR OF THE TURNER VALLEY FIELD. THE RESULT WAS A PRODUCT HIGH IN NATURAL GASOLINE, AN ITEM IN CONSIDERABLE DEMAND AT THAT TIME. ASSOCIATED NATURAL GAS FOR THE MOST PART WAS UNWANTED AND FLARED AFTER PASSING THROUGH WELL-SITE SEPARATORS. AS THE DEMAND FOR NATURAL GASOLINE DECLINED AND THAT FOR NATURAL GAS INCREASED, ROYALITE DECIDED TO BUILD A CENTRAL PLANT TO PROCESS THE GAS THAT PREVIOUSLY HAD PASSED THROUGH THESE WELL-SITE SEPARATORS. THUS, THE ORIGINAL TURNER VALLEY PLANT WAS ESTABLISHED IN 1933.

CRUDE OIL PRODUCTION SHOWED FURTHER EXPANSIONS THROUGHOUT THE 1930'S AND 40'S. EVEN IN THE MID-1950'S APART FROM FACILITIES IN ACHESON, BONNIE GLEN, REDWATER AND TURNER VALLEY, THE NATURAL GAS PRODUCED IN CONJUNCTION WITH THIS CRUDE OIL WAS BURNED OFF TO THE ATMOSPHERE IN FLARE STACKS. OF COURSE, NO SUMMARY WOULD BE COMPLETE WITHOUT MENTION OF THE IMPORTANT DISCOVERIES AT DEVON-LEDUC 1947 - 1951.

IN 1951 WITH THE FIRST SOUR GAS WELLS AT JUMPING POUND, SHELL INSTALLED A ONE STAGE CLAUS SULPHUR RECOVERY UNIT OF 80% EFFICIENCY AS A RESULT OF THEIR CONCERN

FOR POSSIBLE AIR POLLUTION PROBLEMS AND AS A CONSERVATION MEASURE. THE PLANT WAS DESIGNED FOR THE RECOVERY OF 30 LONG TONS PER DAY (LTD) OF SULPHUR FROM A DESIGNED MAXIMUM INPUT OF 35 MILLION CUBIC FEET PER DAY (MMCFD) OF RAW GAS.

BY 1957 - '58 PIPELINE COMPLETIONS ENABLED ALBERTA OIL AND GAS TO ENTER ONTARIO AND U.S. MARKETS. THIS HAD A TREMENDOUS IMPACT ON SULPHUR PRODUCTION IN THE FOLLOWING WAY. WHILE THE SHELL JUMPING POUND PLANT WAS BASED ON 3 - 4% HYDROGEN SULPHIDE IN THE RAW FEED STOCK, THE EXPANDED MARKETS FOR NATURAL GAS AND SULPHUR MADE IT FEASIBLE IN 1959 AND 1961, FOR THE OKOTOKS AND PETROGAS CROSSFIELD PLANTS TO PROCESS RAW GAS CONTAINING 33 - 34% HYDROGEN SULPHIDE. UNDER THESE CONDITIONS THE PERCENTAGE INCREASE IN SULPHUR RECOVERED WAS GREATER THAN THE PERCENTAGE INCREASE OF ASSOCIATED MARKETABLE NATURAL GAS. THE RESULT WAS THAT SULPHUR PRODUCTION INCREASED FROM 45,000 LONG TONS PER YEAR IN 1957 TO 1.3 MILLION LONG TONS PER YEAR IN 1963 AND ADDITIONALLY AT THE RATE OF 10% PER YEAR BETWEEN 1963 AND THE BEGINNING OF 1967. BY THE END OF 1967 SULPHUR PRODUCTION STOOD AT 2.2 MILLION LONG TONS PER YEAR, ALMOST DOUBLE THE 1963 OUTPUT. A NEARLY 30% INCREASE OF SULPHUR PRODUCTION IN 1967 WAS DUE PRINCIPALLY TO THE COMMISSIONING OF THE PETROGAS PLANT AT BALZAC AND THE CANADIAN SUPERIOR PLANT AT HARMATTAN, THE LATTER PROCESSING RAW GAS CONTAINING 52% HYDROGEN SULPHIDE.

A FURTHER UPSURGE IN THE U.S. ECONOMY, COUPLED WITH NEW PIPELINE OUTLETS TO THE U.S. MIDWEST, PLUS INCREASING CONCERN WITH POLLUTION ABATEMENT IN CANADA, PUSHED SULPHUR PRODUCTION OVER 3 MILLION LONG TONS PER YEAR IN 1968 AND UP TO 3.8 MILLION IN 1969. BY THE END OF 1971 SULPHUR PRODUCTION REACHED 4.5 MILLION TONS PER YEAR.

2.1.1 CURRENT STATUS

FROM THREE PLANTS PROCESSING NATURAL GAS IN 1947 THE INDUSTRY HAS EXPANDED TO A PRESENT 152 PLANTS, SIXTY-SEVEN OF WHICH PROCESS SOUR GAS. OF THESE SIXTY-SEVEN SOUR GAS PLANTS, FORTY-TWO ARE REQUIRED TO RECOVER ELEMENTAL SULPHUR AS A BY-PRODUCT. THE TWENTY-FIVE PLANTS NOT REQUIRED TO RECOVER SULPHUR BURN THEIR HYDROGEN SULPHIDE AND RELEASE THE SULPHUR TO THE ATMOSPHERE AS SULPHUR DIOXIDE. AS OF MARCH 1972, THE 152 PLANTS HAD A TOTAL DESIGN CAPACITY FOR PROCESSING 12,000 MILLION CUBIC FEET PER DAY OF RAW GAS GATHERED THROUGH 32,000 MILES OF PIPE. FROM THIS RAW GAS 10,000 MILLION CUBIC FEET PER DAY OF NATURAL GAS COULD BE RECOVERED. IN ADDITION, THESE PLANTS WERE CAPABLE OF PRODUCING 116,000 BARRELS PER DAY (B/D) OF PROPANE, 70,500 BARRELS PER DAY OF BUTANES, 256,000 BARRELS PER DAY OF PENTANES PLUS AND OVER 24,000 LONG TONS PER DAY OF SULPHUR AT AN OVERALL AVERAGE RECOVERY EFFICIENCY OF 95%.

2.2 NUMERICAL COMPARISON OF KEY STANDARDS

TABLE 1 COMPARES SO_2 AMBIENT AIR QUALTIY STANDARDS FOR ALBERTA WITH CANADIAN FEDERAL, ONTARIO PROVINCIAL AND U.S. FEDERAL STANDARDS. THE ALBERTA PROVINCIAL STANDARDS ARE GENERALLY MORE STRINGENT THAN THOSE FROM OTHER AREAS. FOR EXAMPLE, THE ALBERTA 24-HOUR 0.1 PPM IS TIGHTER THAN BOTH THE CANADIAN AND U.S. FEDERAL MAXIMUM ACCEPTABLE AND PRIMARY STANDARDS, RESPECTIVELY. IT IS THE SAME AS THE U.S. FEDERAL SECONDARY AND ONTARIO 24-HOUR STANDARD, BUT NOT AS STRINGENT AS THE PROPOSED CANADIAN MAXIMUM DESIRABLE LIMIT OF 0.06 PPM.

ON A SHORTER TIME FRAME, THE ALBERTA 1-HOUR 0.3 PPM FALLS IN BETWEEN THE CANADIAN FEDERAL ACCEPTABLE MAXIMUM AND THE ONTARIO STANDARD. A DIRECT COMPARISON

CANNOT BE MADE WITH A U.S. 1-HOUR STANDARD; HOWEVER, IT IS POSSIBLE TO APPROXIMATE THE U.S. SECONDARY 3-HOUR STANDARD TO A 1-HOUR TIME FRAME. BY DOING THIS, THE U.S. SECONDARY 1-HOUR STANDARD WOULD BE 0.62 PPM, MORE THAN DOUBLE WHAT WE HAVE IN ALBERTA.

TABLE 1

COMPARATIVE AMBIENT AIR QUALITY STANDARDS
FOR SULPHUR DIOXIDE

(ALL VALUES IN PPM BY VOLUME)

TIME FRAME

	1/2 (HR)	1 (HR)	3(HRS)	24 (HRS)	ANNUAL ARITHMETIC AVERAGE
ALBERTA		0.30		0.10	
MAXIMUM ALLOWABLE CALCULATED GLC'S					
URBAN AND AGRICUL. AREAS	0.2				
OTHER AREAS	0.3				
FLARING EMERGENCIES	1.0				
ONTARIO.		0.25		0.10	0.02
CANADIAN FEDERAL (1) MAX. ACCEPTABLE		0.34		0.11	0.02
MAX. DESIRABLE		0.17		0.06	0.01
U.S. FEDERAL EPA PRIMARY				0.14	0.03
SECONDARY		0.62[2]	0.5	0.10	0.02
HARMFUL (3)				1.0	

(1) PROPOSED (2) ESTIMATED VALUE (3) NOT A STANDARD, BUT A GUIDELINE

2.3 CRITERIA FOR AIR QUALITY STANDARDS

2.3.1 HEALTH EFFECTS OF SO_2

OVER THE LAST SEVERAL YEARS, THERE HAS BEEN QUITE A BIT OF CRITICISM IN THE UNITED STATES OF THEIR NATIONAL PRIMARY AND SECONDARY AIR QUALTIY STANDARDS. IN GENERAL, THE U.S. PRIMARY STANDARD WAS SUPPOSEDLY SET TO PROTECT PUBLIC HEALTH, AND THE SECONDARY STANDARD TO PROTECT STRUCTURES AND CROPS. MANY PAGES OF TESTIMONY AND PUBLISHED REPORTS, BY QUALIFIED MEDICAL AND SCIENTIFIC AUTHORITES HAVE MADE IT CLEARTHAT THERE IS BY NO MEANS A UNANIMITY OF OPINION AS TO WHAT CONCENTRATIONS, OTHER THAN HEAVY LOADS OF SULPHUR OXIDES, IN THE AMBIENT AIR ARE DAMGEROUS TO HEALTH.

SOME EXPERTS IN THE U.S. INSISTED THAT EVEN THOUGH PROOF OF SULPHUR OXIDE INJURY WAS LACKING, THE SUSPICION THAT THESE SUBSTANCES ARE INJURIOUS WAS SUFFICIENT TO JUSTIFY THE ESTABLISHMENT OF RIGID STANDARDS. ON THE OTHER HAND, A SUBSTANTIAL NUMBER OF AUTHORITES ARE CONVINCED THAT THE EVIDENCE AGAINST SULPHUR OXIDES, PARTICULARLY AT THE LOW LEVELS FOUND IN MANY AREAS, IS SO TENUOUS THAT THERE IS NO JUSTIFICATION FOR SETTING LOW NUMERICAL LIMITATIONS. LET ME QUOTE FROM AN AIR AND WATER NEWS PUBLICATION (MCGRAW-HILL, APRIL 10TH, 1967) REPORTING ON THE U.S. FEDERAL AIR QUALITY CRITERIA:

"A NUMBER OF INDUSTRIAL TOXICOLOGISTS AND MEDICAL DOCTORS WHO HAVE REVIEWED THE (U.S. HEW SULPHUR OXIDES) CRITERIA FEEL THAT THE RESEARCH WORKS CITED AS JUSTIFICATION FOR THE CRITERIA ARE FREQUENTLY VAGUE, INCOMPLETE OR QUOTED OUT OF CONTEXT. WHILE THERE IS NO ARGUMENT CONCERNING THE UPPER NUMBERS IN THE MORBIDITY AND MORTALITY RANGE, THERE IS SUBSTANTIAL SKEPTICISM CONCERNING

THE WORK DONE TO JUSTIFY THE LOWER NUMBERS."

RECENTLY A U.S. FEDERAL COURT HANDED DOWN A RULING WHICH REQUIRES THE U.S. ENVIRONMENTAL PROTECTION AGENCY TO SHOW WHAT SCIENTIFIC PROOF WAS USED AS THE BASIS FOR SETTING THE U.S. SECONDARY AMBIENT AIR QUALTIY STANDARD FOR SO_2. THE COURT IS STILL WAITING FOR EPA'S REPLY. I MENTION THESE POINTS BECAUSE THE U.S. AIR QUALITY STANDARDS HAVE HAD SIGNIFICANT INFLUENCE ON OUR OWN STANDARDS.

MOVING CLOSER TO HOME, IT HAS BEEN POINTED OUT IN EARLIER TESTIMONY THAT OPERATING UNDER THE EXISTING ALBERTA AIR QUALITY STANDARDS NATURAL GAS PROCESSING AND SULPHUR RECOVERY PLANTS, AND OTHER INDUSTRIAL PROCESSES INVOLVING THE EMISSION OF SO_2, DO NOT PRODUCE ANY HEALTH HAZARD IN THE VICINTY OF SUCH OPERATIONS. SURVEYS TAKEN IN THE VICINTY OF THE GCOS OPERATION SUPPORT THIS GENERAL CONCLUSION.

I WOULD NOW LIKE TO COMMENT ON FLARING AND EMERGENCY CONDITIONS. THE ALBERTA MAXIMUM ALLOWABLE GROUND-LEVEL CONCENTRATION OF 1 PPM, DURING FLARING EMERGENCIES, APPEARS TO BE MORE THAN ADEQUATE TO PROTECT PUBLIC HEALTH. FOR EXAMPLE, THE THRESHOLD LIMIT VALUE FOR SO_2 ADOPTED BY THE AMERICAN INDUSTRIAL HYGIENISTS IS 5 PPM FOR 8-HOURS PER DAY, 5 DAYS PER WEEK, WHICH IS MANY TIMES HIGHER THAN "1 PPM MAXIMUM ACCEPTABLE FOR LESS THAN 1-HOUR WHICH OUR PROVINCE SPECIFIES." THE U.S. ENVIRONMENTAL PROTECTION AGENCY ON AUGUST 14, 1971 PUBLISHED "EPISODE CRITERIA" WHICH GAVE VARIOUS LEVELS OF POLLUTION WHICH EPA CONSIDERS TO BE SERIOUS ENOUGH TO WARRANT SPECIAL PRECAUTIONS. THE THREE LEVELS FOR SO_2 ARE:

ALERT.. 0.3 PPM FOR 24 HOURS

WARNING.. 0.6 PPM FOR 24 HOURS

EMERGENCY.. 0.8 PPM FOR 24 HOURS

AS THESE VARIOUS EPISODE STAGES ARE REACHED, INDUSTRIAL BUSINESS AND PUBLIC FACILITIES MUST BEGIN TO CUT BACK ON THE USE OF EMISSION PRODUCING OPERATIONS AND SWITCH TO ALTERNATE FUELS. IF THE EMERGENCY STAGE IS REACHED FOR 24-HOURS, MOST INDUSTRIAL AND BUSINESS ACTIVITY WOULD BE CURTAILED. I WANT TO EMPHASIZE THAT THE SO_2 AIR QUALITY DETERMINED NECESSARY TO WARRANT SUCH DRASTIC ACTION IS 0.8 PPM FOR 24 HOURS WHICH AGAIN IS ORDERS OF MAGNITUDE HIGHER THAN THE ALBERTA CRITERIA. SEVERAL MONTHS AFTER PUBLICATION OF THE PREVIOUSLY MENTIONED EPISODE CRITERIA, EPA PUBLISHED WHAT THEY CONSIDERED WERE HARMFUL LEVELS OF POLLUTANTS. THE VALUE FOR SO_2 WAS SET AT 1 PPM FOR 24 HOURS.

IT SEEMS TO US THAT CONSIDERABLY MORE DEBATE HAS TAKEN PLACE IN THE U.S. ON THIS ISSUE THAN HAS TAKEN PLACE IN CANADA, AND WE THINK THE ENVIRONMENT CONSERVATION AUTHORITY SHOULD STEP BACK AND ANALYZE THE CURRENT PROVINCIAL REGULATIONS BASED ON THE OVERALL REQUIREMENTS OF THE PROVINCE.

THE POINT TO BE MADE HERE IS THAT WE, IN ALBERTA, ARE FACED WITH VERY STRICT AIR QUALITY STANDARDS, PROBABLY MUCH MORE SEVERE THAN NECESSARY TO PROTECT OUR CITIZENS; AND, UNDER NEARLY ALL CIRCUMSTANCES WE ARE MEETING THESE STANDARDS. SPECIFICALLY, AROUND SULPHUR RECOVERY OPERATIONS, WE ARE MEETING THE AIR QUALTIY STANDARDS WITHOUT THE USE OF SO-CALLED SECONDARY TAIL-GAS RECOVERY FACILITIES. WE CONTEND THAT FROM THE STANDPOINT OF PROTECTING PUBLIC HEALTH WE SEE NO VALID REASONS FOR TIGHTENING CURRENT AMBIENT AIR QUALTIY STANDARDS,

OR REQUIRING THE USE OF SECONDARY TAIL-GAS RECOVERY FACILITIES ON SULPHUR PLANTS.

2.3.2 HEALTH EFFECTS FROM OTHER SULPHUR COMPOUNDS

SULPHURIC ACID MIST IS FORMED IN THE ATMOSPHERE FROM THE RELATIVELY SLOW OXIDATION OF SO_2. THE THRESHOLD LIMIT VALUE FOR SO_3 HAS BEEN ESTABLISHED AT 1 MILLIGRAM/M^3 OF AIR, 8 HOURS PER DAY, 5 DAYS PER WEEK. THIS COMPOUND IS MORE OF AN IRRITANT TO MAN AND ANIMALS THAN EQUAL AMOUNTS OF SO_2. MEASUREMENTS OF SO_3 IN URBAN ATMOSPHERES, HOWEVER, SELDOM YIELD VALUES IN EXCESS OF 0.10 MILLIGRAM/M^3.

HYDROGEN SULFIDE CAN BE A VERY DANGEROUS GAS IN HIGH ENOUGH CONCENTRATIONS; BUT, DUE TO ITS RAPID DISAPPEARANCE IN THE ATMOSPHERE, IT IS NOT CONSIDERED A HEALTH HAZARD.

2.3.3 EFFECTS ON VEGETATION AND SOIL

IT IS GENERALLY RECOGNIZED THAT SO_2 VALUES ON THE ORDER OF 1 PPM FOR 1-HOUR, OR 0.25-0.3 PPM FOR 8-HOURS ARE REQUIRED TO PRODUCE SO_2 STRESS IN VEGETATION. IN GENERAL THEN, THE ALBERTA STANDARDS ARE STRICT ENOUGH TO PROTECT VEGETATION.

STRESSES IN VEGETATION HAVE BEEN REPORTED IN THE VICINITY OF SULPHUR RECOVERY OPERATIONS; HOWEVER, IN NEARLY ALL CASES THEY HAVE BEEN DUE TO NATURAL CAUSES. INSECT INFECTIONS, FOR EXAMPLE CAN BE EASILY MISINTERPRETED AS SO_2 DAMAGE. VERY LITTLE STRESS DUE TO SULPHUR COMPOUNDS HAS BEEN REPORTED EXCEPT NEAR SULPHUR STORAGE AREAS. SULPHUR DUST CAN BECOME AIRBORNE, AND IN THE IMMEDIATE VICINITY (½ TO 1 MILE) OF THE PLANT, CAN CAUSE VEGETATION DAMAGE AS WELL AS A CHANGE IN THE SOIL PH.

INFORMATION FROM RECENT STUDIES SHOW THAT VEGETATION AND SOIL DAMAGE ONLY OCCUR IN THE IMMEDIATE VICINITY OF THE PLANT AND THAT THIS DAMAGE IS APPARENTLY DUE TO SULPHUR DUSTING IN THE STORAGE AREA, THERE IS NO REASON TO REQUIRE HIGHER PERCENT RECOVERIES ON SULPHUR PLANTS.

THIS PROBLEM ATTRIBUTED TO SULPHUR DUST WILL NOT BE SOLVED BY REDUCING THE VOLUME OF SO_2 RELEASED FROM A TALL STACK FROM 15,000 PPM'S DOWN TO 1,000 PPM'S OR LESS. WE SHOULD SOLVE THE IDENTIFIABLE PROBLEMS AT HAND RATHER THAN SIMPLY TRYING TO IMPOSE VERY STRICT EMISSION LIMITATIONS WHICH YIELD US LITTLE OR NO BENEFIT.

PART 3

GREAT CANADIAN OIL SANDS LIMITED

THE TOTAL PROJECT IS CLOSELY INTEGRATED AND DESIGNED TO BE SELF SUFFICIENT, BY PRODUCT COKE PRODUCED IN REFINING THE BITUMEN PROVIDES FUEL TO GENERATE THE LARGE QUANTITIES OF STEAM AND ELECTRIC POWER NEEDED FOR THIS VAST MINING AND PROCESSING OPERATION.

3.1 DESCRIPTION OF MINE AND EXTRACTION

OPEN PIT MINING UTILIZING THREE GIANT BUCKET WHEEL EXCAVATORS AND AN EXTENSIVE SYSTEM OF CONVEYORS PRODUCES AN AVERAGE OF 130,000 TONS PER DAY OF TAR SANDS. THE OPERATION IS CONTINUOUS, AND IS SUBJECT TO WINTER CONDITIONS AS LOW AS -60^{o}F.

THE MINED TAR SANDS ARE MIXED WITH WATER AND STEAM AND PROCESSED IN ROTATING DRUMS WHICH DISCHARGE INTO SEPARATION CELLS WHERE THE BITUMEN FLOATS TO THE SURFACE AND IS RECOVERED BY SKIMMING. THE MIXTURE OF WATER, SAND AND CLAY IS REMOVED AS TAILINGS. THE SOLIDS ARE RETURNED TO THE LEASE AND THE EXCESS WATER IS RECYCLED BACK TO THE PROCESS.

3.2 PROCESS AREA

3.2.1 DELAYED COKING UNIT

IN THE DELAYED COKER, BITUMEN IS HEATED TO A TEMPERATURE OF ABOUT 900^{o}F BEFORE PASSING INTO 3 PAIRS OF COKE DRUMS. A COMBINATION OF TIME AND TEMPERATURE IN THESE DRUMS RESULTS IN THE FORMATION OF COKE AND HYDROCARBON

VAPOURS. WHEN THE COKE DEPOSITED IN THE DRUMS REACHES THE MAXIMUM PERMITTED DRUM LEVEL, FLOW IS SWITCHED TO A FRESH DRUM WHILE THE COKE FROM THE FIRST DRUM IS REMOVED HYDRAULICALLY. THREE SUCH SWITCHES ARE PERFORMED EACH DAY. ALTHOUGH GREAT CARE AND CAUTION ARE EXERCISED, EACH SWITCH CREATES A SURGE FELT THROUGHOUT THE DOWN-STREAM PLANT. THE VAPOURS PASS TO THE COKER FRACTIONATOR WHERE THE HYDROCARBONS ARE SEPARATED INTO GAS OIL, KEROSENE, NAPHTHA AND GAS.

3.2.2 GAS RECOVERY UNIT

THE NAPHTHA AND GAS STREAMS ARE SENT TO THE GAS RECOVERY SECTION WHERE AN ABSORBER AND SPONGE COLUMN PRODUCE A FUEL GAS FREE OF BUTANE AND HEAVIER HYDROCARBONS. THIS GAS CONTAINS ABOUT 12% H_2S AND GOES DIRECTLY TO THE SULPHUR PLANT FOR REMOVAL OF H_2S. THE HEAVIER HYDROCARBONS ARE FURTHER FRACTIONATED TO STABLIZE THE NAPHTHA AND A C_4/C_5 CUT IS REMOVED OVERHEAD. THE STABILIZED NAPHTHA IS USED AS MAKE-UP DILUENT TO THE EXTRACTION SECTION AND FEED TO THE NAPHTHA UNIFINER AND AS ABSORBING OIL.

3.2.3 UNIFINING UNITS

THE STABILIZED NAPHTHA, KEROSENE AND GAS OIL FRACTIONS ARE EACH SENT TO A SEPARATE UNIFINER TO DECOMPOSE AND REMOVE SULPHUR COMPOUNDS, NITROGEN COMPOUNDS AND TO SATURATE UNSTABLE HYDROCARBONS PRODUCED IN COKING.

EACH UNIFINER CONSISTS OF A REACTION SECTION AND A STRIPPING/FRACTIONATION SECTION. IN THE REACTION SECTION THE HYDROCARBON IS MIXED WITH HYDROGEN FROM THE HYDROGEN UNIT, HEATED AND CONTACTED OVER A NICKEL/MOLYBDENUM CATALYST

WHICH PROMOTES THE DESULPHURIZING REACTION. SULPHUR COMPOUNDS ARE CONVERTED TO H_2S AND NITROGEN COMPOUNDS TO AMMONIA. UNIFINING REACTIONS REQUIRE VERY SEVERE CONDITIONS, PRESSURES UP TO 1500 PSIG AND TEMPERATURES UP TO 800^{o}F. THE CONSTANT CHANGE IN FEED COMPOSITION DUE TO THE BATCH TYPE OPERATION OF THE COKERS MAKES IT MORE DIFFICULT TO MAINTAIN STEADY CONDITIONS ON THESE UNIFINING UNITS.

THE CATALYST INVENTORY OF THE THREE UNITS (700,000 LB) IS WORTH APPROXIMATELY 3/4 MILLION DOLLARS. OPERATING UPSETS SUCH AS A SHARP REDUCTION IN HYDROGEN PARTIAL PRESSURE CAN RESULT IN CATALYST DEACTIVATION DUE TO COKE LAYDOWN. CATALYST DAMAGE CAN RESULT IN A PLANT SHUTDOWN FOR REGENERATION OR REPLACEMENT OF CATALYST.

THE PRODUCT FROM THE REACTORS IS CHARGED TO THE STRIPPING/FRACTIONATION SECTION WHERE AN H_2S RICH GAS IS STRIPPED OUT OF THE LIQUID HYDROCARBON AND ROUTED TO THE SULPHUR PLANT. THIS GAS ALSO CONTAINS AMMONIA. MAINTENANCE OF CONSTANT CONDITIONS IS ESSENTIAL TO AVOID HEAVY HYDROCARBONS IN THE GAS.

3.2.4 HYDROGEN UNIT

THE HYDROGEN UNIT CONVERTS GAS INTO HYDROGEN FOR USE IN THE UNIFINERS. THE FEED GAS, A MIXUTRE OF NATURAL GAS AND SWEETENED REFINERY GAS FROM THE AMINE SECTION IS FIRST PRETREATED OVER COBALT/MOLYBDENUM AND ZINC OXIDE CATALYSTS FOR SATURATION OF OLEFINS AND REMOVAL OF TRACE QUANTITIES OF SULPHUR COMPOUNDS. IT IS THEN CONTACTED WITH STEAM OVER A NICKEL CATALYST AT TEMPERATURES OF ABOUT 1500^{o}F AND PRESSURE OF ABOUT 350 PSIG, IN A REFORMING FURNACE. HYDROGEN, CARBON MONOXIDE AND CARBON DIOXIDE ARE PRODUCED IN THE REFORMING REACTIONS.

DOWN STREAM OF THE REFORMER THE GAS AND STEAM ARE FURTHER CONTACTED OVER IRON OXIDE AND COPPER CATALYSTS FOR CONVERSION OF THE CO TO CO_2 AND H_2. THE HYDROGEN IS PURIFIED TO ABOUT 95% BY REMOVAL OF CO_2 IN THE PURIFICATION SECTION.

SMOOTH OPERATION OF THE HYDROGEN PLANT IS ESSENTIAL NOT ONLY TO PREVENT DAMAGE TO THE CATALYST AND THE HUGE REFORMING FURNACE, BUT ALSO TO ENSURE THAT THE UNIFINERS ARE SUPPLIED WITH A CONTINUOUS AND STEADY SOURCE OF HYDROGEN. ANY UPSET IN THE HYDROGEN PLANT WILL IMMEDIATELY AFFECT THE UNIFINERS AND A SHUTDOWN OF THE HYDROGEN PLANT WILL CAUSE A SHUTDOWN OF THE UNIFINERS.

3.2.5 SULPHUR PLANT - AMINE SECTION

THE SOUR GAS STREAMS FROM THE COKER/GAS RECOVERY UNIT AND UNIFINERS ARE ROUTED TO THE AMINE SECTION AND ARE CONTACTED IN TWO ABSORPTION TOWERS WITH CIRCULATING MONOETHANOLAMINE (MEA) WHICH ABSORBS THE H_2S. THE H_2S IS THEN STRIPPED FROM THE MEA IN A REGENERATOR COLUMN AND ROUTED TO THE SULPHUR RECOVERY SECTION.

3.2.6 SULPHUR RECOVERY SECTION

THE SULPHUR RECOVERY SECTION IS A TWO STAGE CLAUS UNIT CONSISTING OF A REACTION BOILER, TWO INLINE BURNERS AND TWO CONVERTERS CONTAINING ACTIVATED BAUXITE CATALYST. CONDENSED LIQUID SULPHUR FLOWS TO A PIT FROM WHICH IT IS PUMPED TO A SULPHUR STORAGE PAD. TAIL GAS FROM THE UNIT GOES TO AN INCINERATOR WHERE ANY REMAINING SULPHUR COMPOUNDS ARE OXIDIZED TO SO_2 AND ROUTED TO THE ATMOSPHERE VIA A 350 FOOT STACK.

3.2.7 SULPHUR PLANT - PROCESS VARIABLES

THE CONVERSION OF H_2S TO SULPHUR TAKES PLACE OVERALL BY THESE REACTIONS:

H_2S +	$1\frac{1}{2}\ O_2$	=	SO_2 +	H_2O	(1)
HYDROGEN SULPHIDE	OXYGEN		SULPHUR DIOXIDE	WATER	
$2\ H_2S$ +	SO_2	$\rightleftharpoons$	$3S$ +	$2\ H_2O$	
HYDROGEN SULPHIDE	SULPHUR DIOXIDE		SULPHUR	WATER	

THESE ARE THE MAIN REACTIONS. THERE ARE QUITE A NUMBER OF OTHER REACTIONS TAKING PLACE INVOLVING SULPHUR TRIOXIDE, HYDROGEN, CARBONYL SULPHIDE, CARBON DISULPHIDE ETC. THEY PLAY A RELATIVELY SMALL BUT SOMETIMES SIGNIFICANT PART IN THE OVERALL CONVERSION OF HYDROGEN SULPHIDE TO SULPHUR.

IN THE REACTION BOILER ONE THIRD OF THE HYDROGEN SULPHIDE IS OXIDIZED TO SULPHUR DIOXIDE. SOME OF THE PRODUCT SULPHUR (ABOUT 60%) IS FORMED IN THE HIGH TEMPERATURE (ABOUT 2200°F) SECTION OF THE BOILER. THE REMAINDER IS FORMED AT MUCH LOWER TEMPERATURES IN THE CATALYTIC REACTORS DOWN STREAM. THE REACTION BOILER AND EACH CATALYTIC CONVERTER ARE FOLLOWED BY CONDENSERS WHERE PRODUCT SULPHUR IS CONDENSED AND DRAINED TO STORAGE. TAIL GAS FROM THE FINAL CONDENSER IS INCINERATED TO CONVERT THE REMAINING H_2S AND ORGANIC SULPHUR COMPOUNDS TO SO_2.

3.2.7.1 FACTORS AFFECTING CONVERSION

$H_2S:SO_2$ RATIO - THE REACTANTS H_2S AND SO_2 MUST BE PRESENT IN THE CORRECT PROPORTION OF 2:1 FOR MAXIMUM CONVERSION. THIS RATIO REPRESENTS THE MAIN CONTROL POINT IN ANY SULPHUR PLANT. DEVIATION IN EITHER DIRECTION FROM 2:1 CAN CAUSE SUBSTANTIAL LOSS OF EFFICIENCY. THE RATIO IS DETERMINED BY ANALYSING THE TAIL

GAS AND THEN ADJUSTING THE COMBUSTION AIR. IN MANY PLANTS THE LABORATORY DOES THE ANALYSIS BUT AUTOMATED METHODS ARE BECOMING COMMON TO IMPROVE PLANT CONTROL GCOS USES A CHROMATOGRAPH ON THE TAIL GAS TO GIVE CONTINUOUS INDICATION OF H_2S, SO_2 CONCENTRATION.

ONE OF THE GREAT ENEMIES OF GOOD RATIO CONTROL IS HYDROCARBON IN THE FEED GAS. THE HYDROCARBON CONSUMES LARGE QUANTITIES OF AIR AND MUST BE COMPENSATED FOR TO MAINTAIN THE CORRECT $H_2S:SO_2$ RATIO. THE HYDROCARBON DEPENDS MOSTLY ON OPERATION OF THE UPSTREAM AMINE UNIT. IN A REFINERY SITUATION, SUCH AS GCOS, THIS UNIT IS SUBJECTED TO A WIDE VARIETY OF FEED STREAMS, CONDITONS AND HYDRO-CARBON TYPES. OLEFINIC GASES, FOR EXAMPLE, ARE VERY COMMON IN REFINERIES, ARE MORE READILY ABSORBED IN AMINE SOLUTIONS AND FIND THEIR WAY TO THE SULPHUR UNIT.

ANOTHER OCCASIONAL PROBLEM WITH RATIO CONTROL IS FEED GAS RATE TO THE SULPHUR PLANT. IF IT GETS LOW ENOUGH (ABOUT 20-30% OF DESIGN), THE AIR CONTROL VALVE OPERATES ALMOST CLOSED AND ITS CONTROL CAPABILITY BECOMES UNSTABLE. THE 2:1 RATIO IS VERY DIFFICULT TO MAINTAIN UNDER THESE CIRCUMSTANCES. LOW FEED RATES ARE TO BE EXPECTED FROM TIME TO TIME IN ANY LARGE COMPLEX SUCH AS A TAR SANDS FACILITY, SIMPLY BECAUSE OF THE MANY SOURCES OF H_2S. STARTUPS AND SHUTDOWNS OF THE ENTIRE COMPLEX ARE A NECESSARILY DELIBERATE PROCESS AND WILL RESULT IN PERIODS OF LOW FEED TO THE SULPHUR PLANT.

3.2.7.2 TEMPERATURE

IN THE CATALYTIC REACTORS THE EQUILIBRIUM CONVERSION TO SULPHUR IS DEPENDENT ON

TEMPERATURE, WITH LOWER TEMPERATURES FAVOURING THE REACTION. UNFORTUNATELY, ONE CANNOT LOWER THE TEMPERATURE IN THE REACTORS BELOW THE DEW POINT OF THE SULPHUR BEING FORMED. SHOULD THIS HAPPEN SULPHUR CONDENSES ON THE CATALYST AND THE REACTION VIRTUALLY STOPS UNTIL THE BED CAN BE HEATED UP ENOUGH TO VAPOURISE THE LIQUID SULPHUR. THIS KIND OF UPSET MAY REPRESENT SEVERAL HOURS OF CONVERSION IN THE 60-70% REGION.

3.2.7.3 HYDROCARBONS IN FEED

THIS AFFECTS CONVERSION IN SEVERAL WAYS BESIDES TENDING TO UPSET THE $H_2S:SO_2$ RATIO:

(1) REACTION PRODUCTS FROM COMBUSTION OF HYDROCARBON (CO_2, H_2O, CO, N_2) ARE INERTS IN THE CLAUS REACTION. THESE DILUENTS REDUCE THE CONCENTRATION OF H_2S AND SO_2, WHICH IS UNFAVOURABLE TO THE EQUILIBRIUM REACTION TO SULPHUR.

(2) ORGANIC SULPHUR COMPOUNDS SUCH AS COS AND CS_2 FORM IN THE REACTION FURNACE. THESE CAN BE CONVERTED TO SULPHUR, BUT MUCH MORE SLOWLY THAN H_2S AND SO_2. THUS, THE MORE SULPHUR TIED UP IN THESE COMPOUNDS, THE LESS IS LIKELY TO BE CONVERTED TO THE ELEMENTAL FORM.

(3) OCCASIONAL SLUGS OF HYDROCARBON IN THE FEED CAN CAUSE COKING OF THE CATALYST, A RESULT OF DEHYDROGENATION AND CRACKING OF HYDROCARBONS (PARTICULARLY OLEFINIC ONES) THAT GET PAST THE OXYGEN-DEFICIENT COMBUSTION STAGE. IN MILD CASES, THE RESULT IS MERELY DISCOLOURED SULPHUR. SOMETIMES THOUGH, THE PLANT MUST BE SHUT DOWN TO BURN THE COKE OFF THE CATALYST (WHICH HASTENS CATALYST DEACTIVATION) OR FOR MECHANICAL CLEANING OF THE CATALYST BED.

3.2.7.4 AMMONIA

THIS IS PRESENT OCCASIONALLY IN NATURAL GAS PLANT SULPHUR UNIT FEEDS, AND QUITE COMMONLY IN REFINERY CLAUS FEEDS. REFINERIES CRACK OR HYDROTREAT FEEDSTOCKS CONTAINING VARYING AMOUNTS OF NITROGEN, CONVERTING IT TO AMMONIA, SOME OF WHICH GETS TO THE AMINE CLAUS UNITS.

IN SMALL CONCENTRATIONS IT IS NOT MUCH OF A PROBLEM OTHER THAN USING UP COMBUSTION AIR AND FORMING INERTS. IN LARGER CONCENTRATIONS, HOWEVER, IT WILL COMBINE WITH H_2S IN THE OXYGEN-DEFICIENT REACTION FURNACE AND FORM FERROUS AMMONIUM SULPHATE WHICH, BEING SOLID AT CONDENSER TEMPERATURES, WILL PLUG THE TUBES AND CAN COMPLETELY SHUT DOWN A PLANT.

3.2.8 FEED SOURCES - SULPHUR PLANT

3.2.8.1 UNIFINER SOUR GASES

THE UNIFINING UNITS ARE COMPLEX REFINERY TYPE PROCESSING FACILITIES REQUIRING SOPHISTICATED CONTROLS AND SKILLED OPERATORS TO ENSURE EFFICIENT, SAFE OPERATION.

THE THREE UNIFINERS PRODUCE FIVE SOUR GAS STREAMS WHICH ARE ROUTED TO THE SULPHUR PLANT AS FEED STOCK. ANY CHANGE, UPSET MECHANICAL FAILURE, ETC., IN ANY OF THESE UNITS, INCLUDING ELECTRICAL POWER, STEAM OR FUEL FAILURES MAY HAVE A MINOR OR MAJOR EFFECT ON THE QUALITY AND QUANTITY OF SOUR GAS PRODUCED.

3.2.8.2 DELAYED COKER SPONGE GAS

THE SPONGE GAS FROM THE DELAYED COKER GAS PLANT IS THE SIXTH AND BY FAR THE

LARGEST SINGLE SOURCE OF FEED STOCK TO THE SULPHUR PLANT. THE GCOS DELAYED COKER, SIMILAR TO THE UNIFINERS, IS ALSO A SOPHISTICATED PROCESS AND CONSTITUTES ONE OF THE LARGEST DELAYED COKER UNITS EVER INSTALLED. A CHARACTERISTIC OF THIS PROCESS IS THE CYCLIC NATURE OF ITS OPERATION REQUIRING CLOSE CO-ORDINATION, PLANNING AND SKILL TO AVOID PROCESS UPSETS AND EQUIPMENT DAMAGE.

3.2.9 HISTORICAL PROBLEMS IN THE GCOS SULPHUR PLANT

FLAME OUTS

DIFFICULTIES WERE EXPERIENCED AT LOW THRUPUT RATES DUE TO FLAME OUT OF THE ACID GAS BURNERS. CONTINUED EFFORTS HAVE BEEN SUCCESSFUL IN MINIMIZING FLAME OUT AND HAVE ACHIEVED IMPROVED REACTION BOILER CONDITIONS WITH SOME PENALTY IN CONVERSION AT REDUCED RATES.

DESIGN

DESIGN INFORMATION ON THE SULPHUR CONTENT OF TAR SANDS BITUMEN WAS LIMITED. THE CAPACITY OF THE PLANT IN PRACTICE PROVED TO BE EXCESSIVE AT PROJECT DESIGN OPERATING LEVELS. THIS RESULTED IN EXCESSIVE COOLING WHICH CAUSED PLUGGAGE OF THE SULPHUR DRAWS.

THE PRESENCE OF SIGNIFICANT QUANTITIES OF AMMONIA IN THE FEED GAS DUE TO NITROGEN REMOVED IN THE UNIFINERS, HAS PRODUCED AN ABNORMAL FEED QUALTIY WHICH LEADS TO FORMATION OF SOLID FERROUS AMMONIUM SULFATE. THIS RESULTS IN FOULING AND PLUGGING OF BOILER TUBES, CONDENSER TUBES, SULPHUR DRAWS AND CALALYST.

ANALYSIS OF STREAMS

MONITORING THE TAIL GAS COMPOSITION IN A SULPHUR PLANT IS THE KEY TO EFFICIENT PERFORMANCE. A CONTINUOUS ANALYZER MONITORING SYSTEM WITH COMPUTERIZED PRINTOUT OF SULPHUR EMISSIONS FROM THE INCINERATOR STACK WAS RECENTLY INSTALLED TO IMPROVE PLANT PERFORMANCE. THESE TWO ELECTRONIC INSTRUMENTS COST APPROXIMATELY $80,000.

3.2.10 TYPICAL PROCESS UNIT SHUTDOWN AND START-UP TIMES

WE ALL RECOGNIZE THAT THE TAKE OFF AND LANDING SEQUENCE IN THE FLIGHT OF AN AIRPLANE IS THE HIGHEST RISK PERIOD OF ANY NORMAL FLIGHT. SIMILARILY IN THE PETROLEUM INDUSTRY, THE START-UP AND SHUTDOWN OF ANY PROCESS UNIT IS NORMALLY THE MOST HAZARDOUS PART OF THE ENTIRE OPERATION.

IT IS CRITICALLY IMPORTANT THAT IN STARTING UP OR SHUTTING DOWN A PROCESS UNIT THIS BE DONE IN A WELL ORDERED SEQUENCE TO ENSURE SAFETY TO BOTH PERSONNEL AND PLANT AND TO AVOID DAMAGE TO EQUIPMENT, MUCH OF WHICH IS OPERATING UNDER EXTREMELY HIGH TEMPERATURES AND PRESSURES HANDLING HIGHLY COMBUSTIBLE, POTENTIALLY EXPLOSIVE, AND IN SOME CASES, TOXIC, CORROSIVE MATERIAL.

WHEN A SHUTDOWN OF THE UNIFINERS IS NECESSARY, CARE HAS TO BE EXERCISED TO PREVENT CATALYST DAMAGE, HYDROGEN ATTACK AND THERMAL STRESS PROBLEMS ON THE VESSELS. SUBSEQUENT START UP REQUIRES SIMILAR CARE. APPROXIMATELY SIX HOURS IS NECESSARY FOR A SHUTDOWN OF A SINGLE UNIFINER AND APPROXIMATELY 24 HOURS IS REQUIRED FOR ITS START UP. IF A SHUTDOWN OF THE HYDROGEN UNIT IS NECESSARY AN ADDITIONAL 18 HOURS IS REQUIRED FOR STARTING THIS UNIT BEFORE THE UNIFINERS CAN BE BROUGHT ON STREAM.

IN THE CASE OF A SHUTDOWN OF THE GAS RECOVERY UNIT, THE COKING AND DILUENT RECOVERY UNITS WILL ALSO HAVE TO BE SHUT DOWN. THE THREE UNITS ARE COMPLETELY INTER-DEPENDENT. A SHUTDOWN WILL TAKE APPROXIMATELY 18 HOURS AND START UP APPROXIMATELY 48 HOURS.

3.2.11 FLARING OF SOUR GAS

THERE ARE SOME SITUATIONS IN WHICH THE COMPLEXITY, INTERDEPENDENCE, AND SAFETY OF THE PLANTS RESULT IN UNAVOIDABLE FLARING OF SOUR GASES. WHEN IT IS NECESSARY TO FLARE SOUR GAS IT IS DONE IN A 250' FLARE STACK USING FUEL GAS EQUIVALENT TO TWICE THE QUANTITY OF HYDROGEN SULPHIDE TO ENSURE COMPLETE COMBUSTION OF HYDROGEN SULPHIDE AND DISPERSION OF SULPHUR DIOXIDE. IF THE SULPHUR PLANT SHUTDOWN IS BRIEF (SAY 6 HOURS), SHUTTING DOWN AND SUBSEQUENT START UP OF THE UPSTREAM UNITS COULD COST 2 DAYS OF SYNTHETIC CRUDE PRODUCTION, PLUS DIRECT H_2S FLARING FOR PART OF THIS TIME.

A SEVERE TOWER UPSET IN A UNIFINER OR THE COKER MAY RESULT IN A QUANTITY OF HIGH BOILING HYDROCARBONS IN THE SOUR GAS STREAM. CHARGING THIS TYPE OF MATERIAL TO THE AMINE SECTION OF THE SULPHUR PLANT CAN CAUSE CARRYOVER OF BOTH HYDROCARBONS AND AMINE TO THE SULPHUR RECOVERY PLANT.

3.3 PERSONNEL PROTECTION

ALL PLANT PERSONNEL ARE GIVEN SAFETY TRAINING INCLUDING IDENTIFICATION OF AND PROTECTIVE MEASURES AGAINST TOXIC GASES. AREAS WHERE THERE IS A POTENTIAL HAZARD FROM HYDROGEN SULPHIDE ARE PROTECTED BY CONTINUOUS, AUTOMATED MONITORING AND ALARM SYSTEMS. GAS MASKS AND BREATHING EQUIPMENT ARE MAINTAINED READILY

AVAILABLE IN APPROPRIATE LOCATIONS. SUPERVISORY PERSONNEL AND A TRAINED SAFETY DEPARTMENT EXERCISE REGULAR INSPECTION AND SURVEILLANCE OF ALL AREAS IN THE PLANT. A STAFFED MEDICAL DEPARTMENT IS AVAILABLE.

3.4 GCOS PERFORMANCE

THE GCOS PROJECT IS A UNIQUE, MAJOR, MINING, EXTRACTION AND REFINING INDUSTRIAL COMPLEX LOCATED IN A REMOTE NORTHERN AREA. IN IT'S INITIAL OPERATION IT FACED MAJOR PROBLEMS OF GATHERING TOGETHER AND DEVELOPING THE NECESSARY HIGHLY SKILLED AND EXPERIENCED ENGINEERING, TECHNICAL, OPERATING AND MAINTENANCE TEAM. THE INITIAL OPERATION UNDER SEVERE WINTER CONDITIONS WAS BADLY CRIPPLED DUE TO A COMPLETE STEAM AND POWER FAILURE WHICH CREATED EXTENSIVE DAMAGE TO PLANT FACILITIES. IT HAS TAKEN TWO AND ONE HALF TO THREE YEARS OF MAJOR EFFORT AND ADDITIONAL INVESTMENT TO BRING THE PROJECT UP TO CONSISTENT LEVELS OF PRODUCTION APPROACHING DESIGN.

DURING THIS EARLY PERIOD, THE SULPHUR PLANT AS WE HAVE ENDEAVOURED TO DESCRIBE, WAS AFFECTED BY THE DIFFICULTIES IN THE REST OF THE ASSOCIATED PROCESSES AND PLANTS. IN ADDITION, THE SULPHUR PLANT ITSELF INITIALLY HAD CERTAIN MECHANICAL PROBLEMS. WITH IMPROVED AND MORE STABLE OPERATION IN THE REST OF THE PROJECT AND CORRECTIONS OF SOME OF THE MECHANICAL PROBLEMS IN THE SULPHUR PLANT, IT HAS BEEN POSSIBLE TO DEVELOP THE TECHNICAL INFORMATION AND ENGINEERING IMPROVEMENTS TO THE EXISTING SULPHUR PLANT WHICH ALREADY HAVE, AND WILL IN THE FUTURE, RESULT IN IMPROVED EFFICIENCY OF SULPHUR RECOVERY AND RELIABLE PLANT OPERATIONS.

3.4.1 PLANNED MODIFICATION STATUS SULPHUR PLANT

THE FOLLOWING IS A SUMMARY OF SOME OF THE MODIFICATIONS AND IMPROVEMENTS TO THE GCOS SULPHUR PLANT WHICH WERE INSTITUTED EARLY IN 1970 AS A RESULT OF THESE ENGINEERING AND TECHNICAL STUDIES.

(1) AS A TEMPORARY MEASURE, TO ACHIEVE AN IMPROVEMENT IN SULPHUR PLANT CONTINUITY OF OPERATION, THE SECOND CONVERTER REACTOR WAS BY-PASSED. WITH CONVERTER REACTORS IN SERIES, WE HAD BEEN UNABLE TO ACHIEVE SATISFACTORY CONTINUITY OF OPERATION DUE TO THE COMBINATION OF EXCESSIVE COOLING SURFACE AND A LOW LEVEL OF CHARGE TO THE PLANT. THIS RESULTED IN LOW TEMPERATURES IN THE SECOND REACTOR AND A TENDENCY FOR SULPHUR TO SOLIDIFY, PLUGGING THE CONDENSER, AND THE CATALYST BED, FORCING FREQUENT PLANT SHUTDOWNS.

(2) ENGINEERING WAS INITIATED TO ACHIEVE BASIC SOLUTIONS TO THE INDICATED PLANT EQUIPMENT PROBLEMS.

THESE WERE:

- MODIFICATION OF REACTION BOILER
- REVAMP OF FIRST AND SECOND STAGE INLINE BURNERS
- REDESIGN AND OVERHAUL OF INSTRUMENTATION, INCLUDING THE BOILER AUTOMATIC FIRE EYE, STREAM METERING FACILITIES AND THE AUTOMATIC TAIL GAS ANALYSER SYSTEM.
- GREATLY ENLARGED LIQUID SULPHUR DRAWS FROM THE REACTION BOILER, BOTH CONVERTERS, THE COOLESCER, AND ALL CONDENSERS.

- IMPROVED CONTROL OF THE SOUR GAS STREAM FROM THE UNIFINERS.
- DESIGN AND INSTALLATION OF A CONTINUOUS COMPUTERIZED SULPHUR MONITORING SYSTEM OF THE INCINERATOR STACK GAS.

MAJOR PIPING IN THE SULPHUR PLANT WAS REDESIGNED TO FACILITATE TWO STAGE OPERATION, AND THE ABILITY TO BY PASS EITHER CONVERTER SYSTEM FOR MAINTENANCE WORK WITH A MINIMUM SHUTDOWN OF THE TOTAL SULPHUR PLANT.

ALL OF THESE CHANGES WERE COMPLETED AND PUT IN SERVICE BY SEPTEMBER 1972, AND THE PLANT RETURNED TO A TWO STAGE OPERATION.

3.4.2 HISTORY OF AMBIENT AIR MONITORING RESULTS

THE AMBIENT AIR CONTINUOUS SULPHUR DIOXIDE AND HYDROGEN SULPHIDE ANALYZERS ARE SITUATED APPROXIMATELY 4 MILES NORTH AND SOUTH OF THE PLANT SITE. SEVERE WEATHER CONDITIONS COMBINED WITH THE ISOLATED LOCATIONS OF THESE INSTALLATIONS AND SOME MECHANICAL PROBLEMS WITH THE ELECTRIC GENERATORS HAS IN THE PAST RESULTED IN INCOMPLETE MONITORING RECORDS. ELECTRICAL POWER AND HEAT FOR THESE UNITS IS SUPPLIED BY A PROPANE GENERATOR AND HEATER. MOST OF THE MECHANICAL PROBLEMS HAVE BEEN SOLVED BUT WINTER CONDITIONS STILL CREATE DIFFICULTIES.

RESULTS OF OUR TOTAL SULPHATION CANDLES SHOW THAT THE AVERAGE ANNUAL LEVELS, WITH ONE EXCEPTION HAVE BEEN WELL UNDER THE ESTABLISHED ALBERTA OBJECTIVES.

TWO PERCENT OF THE MONITORED DATA HAS EXCEEDED THE PROVINCES' AMBIENT AIR STANDARD OF 0.3 PPM, HOWEVER, RARELY HAS THE LEVEL EXCEEDED 0.4 PPM.

SULPHUR PLANT OPERATION HAS IMPROVED OVER THE PAST FEW MONTHS AND MONITORING TRENDS FOR THIS PERIOD APPEAR TO REFLECT IMPROVEMENT.

3.4.3 AFFECT ON ENVIRONMENT

REGULAR SURVEYANCE OF TREES AND VEGETATION SURROUNDING THE PLANT AREA FOR DAMAGE DUE TO SULPHUR COMPOUNDS IS MADE MONTHLY WHEN THE SULPHATION CANDLES ARE MAINTAINED. THESE OBSERVATONS HAVE SHOWN NO EVIDENCE OF ENVIRONMENTAL DEGREDATION.

THESE FIELD OBSERVATIONS OF LACK OF ENVIRONMENTAL DAMAGE ARE FURTHER SUPPORTED BY THEORETICAL CALCULATIONS OF MAXIMUM GROUND LEVEL CONCENTRATONS OF SULPHUR DIOXIDE RESULTING FROM EMISSIONS FROM THE GCOS OPERATIONS WITH THE SULPHUR PLANT RUNNING UNDER FULL LOAD. THESE CALCULATIONS PREDICT A MAXIMUM GROUND LEVEL CONCENTRATION WELL BELOW 0.3 PPM.

CONCLUSIONS

(1) EXISTING ALBERTA AMBIENT AIR QUALITY STANDARDS ARE MORE THAN ADEQUATE TO PROTECT HUMAN HEALTH AS WELL AS ANIMALS, PLANTS AND PROPERTY.

(2) A SULPHUR EXTRACTION PLANT IN A PROCESSING COMPLEX SUCH AS GCOS HAS IMPORTANT DIFFERENCES FROM SULPHUR EXTRACTION PLANTS IN NATURAL GAS PROCESSING. THESE CRITICAL DIFFERENCES REQUIRE TO BE RECOGNIZED IN THE APPLICATION OF REGULATIONS RELATING TO THE SULPHUR DIOXIDE EMISSIONS.

(3) ENVIRONMENTAL REGULATIONS SHOULD CONSIDER EACH GEOGRAPHIC AREA, IT'S NATURE AND CHARACTER, AS WELL AS THE SPECIFIC INDUSTRIAL OPERATIONS WHEN APPLYING EMISSION REGULATIONS. THE COST/BENEFIT RATIO OF MORE SEVERE ENVIRONMENTAL REGULATIONS SHOULD BE DETERMINED TO ENSURE THAT THE COST OF ACHIEVING FURTHER IMPROVEMENTS IN AMBIENT AIR QUALTIY ARE WARRANTED BY THE ENVIRONMENTAL IMPROVEMENTS.

(4) WE BELIEVE THIS TYPE OF HEARING SERVES A USEFUL PURPOSE AND WE APPRECIATE THE OPPORTUNITY OF PARTICIPATING IN THE HEARING HERE TODAY. IT HAS BEEN OUR OBJECTIVE TO MAKE A POSITIVE CONTIRBUTION TO ASSIST THE GOVERNMENT IN DEVELOPING SOUND POLICIES AIMED AT PROTECTING ALBERTA'S ENVIRONMENT.

REFERENCES

(1) SURVEY OF FORT MCMURRAY
ALBERTA GOVERNMENT PUBLICITY BUREAU

(2) WESTERN MINER
SEPTEMBER 1967, VOL. 40 NO. 9

(3) ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS
DR. R.F. KLEMM

(4) REMARKS OF KENNETH F. HEDDON
PRESIDENT GREAT CANADIAN OIL SANDS LIMITED
TO THE CALGARY CHAMBER OF COMMERCE
PALLISER HOTEL, CALGARY, ALBERTA JUNE 15, 1972

(5) ADDRESS TO THE CANADIAN INSTITUTE OF MINING AND METALLURGY (THE PETROLEUM SOCIETY OF C.I.M.) CALGARY, ALBERTA BY HONOURABLE W.J. YURKO MINISTER OF THE ENVIRONMENT,GOVERNMENT OF ALBERTA AUGUST 9, 1972

QUESTIONING BY THE AUTHORITY

DR. S.B. SMITH

Do you think that your plant, with the number of tons it recovers in sulphur, and other plants which may be built in the area will have an impact on sulphur sales in Canada or on the export picture?

MR. F.A. BAIN

Initially the design of the facility was to remove sulphur where it is provided; not with the intent of the economics of sulphur recovery, because at the time they were designed, this wouldn't have warranted recovery. In the meantime the price of sulphur did rise, and for a period of time it appeared like there could be an economic return on the sale of sulphur. However, the situation now is that the sale of sulphur from our operation is essentially nil. The price of moving sulphur out of that remote area almost prohibits it under present economic conditions.

DR. S.B. SMITH

One could expect then that one or more other oil sand recovery plants would be faced with the same problem that the sulphur, at least for a time, will be indefinitely stored in that area rather than sold.

MR. F.A. BAIN

I believe that's true.

DR. S.B. SMITH

You provide a comparison with the E.P.A. standards which permit five parts per million for eight hours per day and followed this with the statement that debate on this matter in the U.S. is more extensive than it is in Canada. Are you suggesting that there is greater knowledge in the U.S., and that the standards therefore can be reasonably accepted as being sufficient; or are you suggesting that they can't do anything about it, that their country is so badly polluted that these are realistic standards?

MR. F.A. BAIN

We felt that the balance between the improvement to be achieved with tighter standards and the cost of receiving it perhaps has not been as fully examined in Canada as it has in the U.S. I am not sure that I feel that the authorities in the U.S. have reflected what we feel is an appropriate balance at this time, but we do feel there has been more public debate on the subject.

DR. S.B. SMITH

Would you agree that in the U.S. in many industrial areas that you can detect much higher levels where there are no sulphur extraction plants, you can still detect many higher levels of SO_2 than we are able to find anywhere in Alberta?

MR. F.A. BAIN

It's my impression that in Alberta in particular, that the SO_2 levels are much lower generally than many of the areas of the U.S. where concern is being expressed, particularly eastern and more industrialized areas of the U.S.

DR. S.B. SMITH

Could you agree that the five parts per million per eight hours per day on a continuous basis may be an approximation of what they are faced with and can't go? below at the present time?

MR. R.A. CONSTABLE

I think the five parts per million is just strictly from an industrial hygiene standpoint. There are no areas in the U.S. that I am aware of that have levels even approaching this. Generally the levels in the U.S., for example in the city of Philadelphia, for most of 1971 and a good part of 1972, are meeting the primary standards for SO_2. Areas such as New York City, which is probably the worst with the reductions in the fuel sulphur content and the switching from coal to oil or to gas, should approach the primary standards by 1975. They are about double the primary standard right now.

DR. S.B. SMITH

Mr. Bain, you indicate the read outs which can be gotten by computerized instrumentation in the incinerator stack. Is this a straight forward instrumentation technology that is available to any plant operation?

MR. F.A. BAIN

Yes, it's one that we have purchased the technology for. It's quite new and it's very sophisticated.

DR. S.B. SMITH

It's available commercially and could be installed in incinerator stacks regardless of whether it's a refining operation or primary sulphur. I am not sure that you gave us the total output, or the total recovery in tons per day.

MR. F.A. BAIN

The design of the plant is indicated at 350. Our actual operating level is proven to be between 250 and 300 tons a day.

DR. S.B. SMITH

My understanding is that it is a common practice both by plants and by government all over the country to use a monitoring system. Is there a statistical design in the placement of monitors around your plant? If there is not, how do you achieve credibility out of the assessment of environment impact on a statistical basis?

MR. F.A. BAIN

The location that we're in at Fort McMurray is one in which there are essentially no roads. It is bush country and forest country around this. The location of the monitoring stations have been locations that have been indicated to us by the Energy Conservation Board along with the Department of the Environment. The location of the monitoring stations however, because of limited accessibility, has not been as complete perhaps as you might hope to have where there are

access roads and more accessible country. These monitoring stations are located to the best advantage that is practical to locate them under the circumstances. Along with our own observations of the area in terms of vegetation damage, we have no evidence of any damage to the vegetation on the basis of the monitoring that we do, and on the basis of our physical field observations.

DR. S.B. SMITH

But you can't compare the monitoring you do with a known area of non-sulphur impact. You can't do this on a statistical basis?

MR. F.A. BAIN

No, we haven't got any statistical data that would be applicable.

MR. W.A. FLOOK

Other than the residents of the Town of Fort McMurray, are there any residents in the area close to the plant?

MR. F.A. BAIN

There are very few residents in that area. The only other settlement of any type is a small Indian location at Fort McKay, roughly twenty miles from our plant.

MR. W.A. FLOOK

There is no voice to complain within twenty miles of the plant? If there were incidents other than the general increase level due to the presence of the plant, if there were a significant incidence, it would probably pass unnoticed unless it were picked up by one of your monitors.

MR. F.A. BAIN

That is correct.

MR. W.A. FLOOK

You have twenty sulphation candles as monitors. Now these are sensing average conditions accumulative over a long period of time. They do not indicate or sense peak incidents.

MR. F.A. BAIN

That is correct.

MR. W.A. FLOOK

The two continuous monitors however do sense peak incidents.

MR. F.A. BAIN

That is correct.

MR. W.A. FLOOK

They are presumably located downwind from the plant?

MR. F.A. BAIN

One is located on the road to Fort McMurray which is roughly south of the plant, and the other location is west of northwest.

MR. W.A. FLOOK

What direction would this be with regard to the prevailing wind?

MR. F.A. BAIN

The prevailing winds are from the northeast to the southwest generally.

MR. W.A. FLOOK

Neither of these locations is directly downwind with regard to the prevailing winds.

MR. F.A. BAIN

The location on the road south of the plant towards the town of McMurray generally would be expected to feel the peaks of the prevailing winds.

MR. W.A. FLOOK

If there were a wind shift of course that instrument would not send anything.

MR. F.A. BAIN

That is correct.

MR. W.A. FLOOK

Its reliability or its usefulness as a monitor is very limited to a small number of incidents.

MR. F.A. BAIN

That is correct.

MR. W.A. FLOOK

You have discovered 2% of incidents where these comparatively ineffective locations have measured excessive quantities of SO_2 in the ambient air.

MR. F.A. BAIN

Our data would indicate some 2% of the data we have that has exceeded the 0.3 standard.

MR. W.A. FLOOK

What is actually happening in fact is that you are exceeding the guidelines considerably more than 2% of the time.

MR. F.A. BAIN

It certainly would. This is only a partial measure of the total area on a two monitor basis.

DR. W.R. TROST

What is the basic sulphur content in the tar sands?

MR. F.A. BAIN

The bitumen in the tar sands runs around four and a half percent sulphur.

DR. W.R. TROST

What is your percent recovery of the sulphur?

MR. F.A. BAIN

The percent recovery of the sulphur should be running roughly in the range of 92 to 94 in a two stage Claus operation. A major portion of the sulphur is removed from the bitumen in the processing that we do, but there are some relatively modest amounts of sulphur still retained in the products as shipped.

DR. W.R. TROST

Is this level of sulphur in the tar sands generally, or does the sulphur content vary over the tar sands area?

MR. F.A. BAIN

I would expect that it would be characteristic of the bitumen.

DR. W.R. TROST

You emit from the incinerator stack how many tons per day of sulphur?

MR. F.A. BAIN

In the range of 20 - 30, probably closer to 20 under normal operating conditions.

DR. W.R. TROST

Is the Claus unit that you use, a standard Claus? As in the gas plant?

MR. F.A. BAIN

Yes.

DR. W.R. TROST

One of the problems that the sulphur extraction gas plants have had arose from terrain and meteorology conditions particularly in the foothills. Have you problems of that sort?

MR. F.A. BAIN

The area that we're in is characterized by the relatively deep valley of the Athabasca River, with some tendency for rolling hills. There is also a tendency, particularly in the winter, to experience inversion conditions which tend to limit the dispersion of gases.

DR. W.R. TROST

Is your winter inversion the Chinook type inversion or are there other kinds of winter inversion?

MR. F.A. BAIN

No, it's not a Chinook type inversion.

DR. W.R. TROST

It may be then a lower level inversion both more extreme and closer to the ground?

MR. F.A. BAIN

I'm not really qualified to comment on the Chinook type inversion, but my feeling would be that they probably can be fairly severe in that area.

DR. W.R. TROST

Do you know what the parts per million of sulphur dioxide in the incinerator stack is at the exit point?

MR. F.A. BAIN

I don't have a number on parts per million.

MR. A.D. GAILBRAITH

With the sulphur plant operating under normal conditions, the sulphur dioxide content would be around 1% or ten thousand parts per million, depending on the throughput of the plant at any specific time.

DR. W.R. TROST

Do you know how the sulphur dioxide is taken up in the winter emissions? It doesn't get frozen in the little ice particles?

MR. F.A. BAIN

I really don't know.

DR. W.R. TROST

Have you done environmental research into possible effects of these emitted gases to find out whether there are in fact any environmental effects or not?

MR. F.A. BAIN

At G.C.O.S. we haven't done any research as such. The lab environmental group is mainly a control type group.

DR. W.R. TROST

Are you aware of the research into the environmental effects of the sulphur extraction plants that has recently been begun by some of the gas companies? Are you associated with it in any way?

MR. A.D. GAILBRAITH

We're aware of it, and our Sun Exploration and Production in Calgary is part of this. Particularly in Whitecourt I imagine that there are problems that are not dissimilar.

DR. W.R. TROST

You have not done any tests to prove the absence or the presence of environmental effects.

MR. F.A. BAIN

Our comments here relate to the physical field observations. We have not observed any effects on vegetation.

DR. W.R. TROST

Is there any difference in your problem in installing tail gas clean up facilities as against the problem for the sulphur extraction gas plants?

MR. F.A. BAIN

Technically, it's quite feasible to install these processes in our operation.

DR. W.R. TROST

It would be technically the same kind of a problem.

MR. F.A. BAIN

To the best of my knowledge. I suppose there may be some complications due to the indicated other contaminants, ammonia in particular. I'm not really aware of any reason to assume that we could not apply them.

DR. W.R. TROST

Such a tail gas clean up, or perhaps even the addition of an extra Claus unit could be incorporated without upsetting the complex balance of the other operations in the plant?

MR. F.A. BAIN

No, it would be a matter of costs here.

DR. W.R. TROST

Your submissions on costs would therefore be the same as those already made to the Authority.

MR. F.A. BAIN

Yes, I would say there is no reason to see a particular difference.

DR. W.R. TROST

Is it not the case that the trend in industrial countries in both U.S. and in Europe in respect of sulphur dioxide emission , particularly when it is associated with burning of fuels, is towards more restrictive standards?

MR. F.A. BAIN

This has certainly been the trend.

DR. W.R. TROST

Is your problem dissimilar or similar in respect to water disposal and how is it handled?

MR. F.A. BAIN

I believe that they have a problem of drying their gas and water; and glycols related to the removal of water are a problem that we are not particularly affected with.

DR. W.R. TROST

Do you have a Claus system for your water or do you ultimately dispose of it?

MR. F.A. BAIN

There is water asssociated with the total complex, but not from the sulphur plant as such.

DR. W.R. TROST

So your water plant is essentially basically different?

MR. F.A. BAIN

That's right. All waters that are emanating from the complex are processed through water treating facilities and are monitored continuously and reported. We have to meet the Alberta standards as far as water quality, so any water from the total project is being closely monitored, controlled and maintained in compliance with the Provincial regulations.

DR. W.R. TROST

Do you think that the more extensive exploitation of tar sand deposits will produce any environmental problems?

MR. F.A. BAIN

I think that the answer has to be yes. At any point when you are installing industrial operations of major consequence there is disruption to normal environmental conditions. This is one of the points that we're trying to emphasize. There has to be a balance between the importance of the economics in the development of these kinds of resources, and the environment that we are trying to protect.

DR. W.R. TROST

All of the sulphur extraction plants formed a co-operative environmental research group, and have been working in a systematic way to follow out environmental effects, particularly on plants. Would such a co-operative research effort commend itself to the tar sands operators, in your view?

MR. F.A. BAIN

Yes, we have been active. The refinery I was associated with was a member of one of the first research groups on environmental matters in Sarnia on the St. Clare River, and this has been expanded over the years into air monitoring and other activities. G.C.O.S. would anticipate and look forward to the benefits of co-operative efforts to try and minimize the impact on the environment of our operations.

DR. W.R. TROST

If that were to come about, if these developments do occur in the tar sands, would you feel that it is sensible, and would you welcome on the committees that set up the programs for the research and receive the results of them, the presence of representatives of the public in the area?

MR. F.A. BAIN

Anybody that is making an objective contribution to solve the problems should be

welcome on such a group. It has been recognized that we are not going to be able to maintain natural environments and have industrial development too. I think that the objective is to try and strike a balance and recognize the relative importance of the factors involved, to try and get the best answer that's possible. Interested parties that have a contribution to make should be welcome.

SUBMISSION

of the

ALBERTA FEDERATION of LABOUR

to the

PUBLIC HEARINGS

respecting

ENVIRONMENTAL EFFECTS

of the operation of

SULPHUR EXTRACTION GAS PLANTS

October, 1972

Presented by: H. Kostiuk

The Alberta Federation of Labour welcomes this opportunity to present, on behalf of organized labour in Alberta, the concerns pertinent not only to our affiliated membership, but to the whole population of this Province.

We are confident that this committee will give the ensuing recommendations and suggestions your most serious consideration, complemented with actions aimed at eradicating the present situation.

EFFECTS ON EMPLOYEES

Upon studying the material which has been compiled as a result of a study done by Dr. R. F. Klemm and other information pertaining to the operation of sulphur extraction gas plants, the Alberta Federation of Labour is quite aware that there is a very large area of concern. At this point, however, we would like to deal with the human health aspect, both off-site and on-site with the hope that the other environmental effects pertaining to wildlife, vegetation, etc., will be covered by other concerned groups and individuals.

At the moment it is recognized that hydrogen sulphide (H_2S) and sulphur dioxide (SO_2) are the two principle substances that are most frequently encountered during the operation. SO_2 is the less lethal of the two substances and fatalities are almost non-existent through its effects. Its properties are such that odor is evident as low as 3 parts per million (ppm) and at concentrations of much over 15 ppm, it is virtually impossible to work. The current established Threshold Limit Value (TLV) for SO_2 is 5 ppm for an eight hour period, five days per week. In past studies conducted it was found that .25 to .30 ppm of SO_2 causes irritation in a significant percentage of humans. This, together with the fact that the odor threshold is only 3 ppm, must certainly raise the question as to why the accepted eight hour TLV's have been placed so high. It is also interesting to note that although the plant workers' TLV's are 5 ppm, the ambient air quality standards for outside environment call for concentrations of no more than .30 ppm. We fail to see the reasoning as to why the worker must be subjected to higher concentrations than the residents living in the surrounding area.

H_2S seems to be the substance which causes the greatest concern in sulphur extraction operations. Although its presence can be detected

through smell in concentrations as low as .03 ppm, as the concentration increases, the sense of smell is deadened. For this reason, unless there are accurate continuous monitoring devices installed, the worker has no way of knowing whether this substance is present in the air or not after a harmful level has been reached. The accepted TLV for H_2S for an eight hour period, five days a week, is 10 ppm. This accepted value again seems to have no relationship whatsoever to the .005 ppm as the maximum accepted for a twenty-four hour period, or a maximum of .03 ppm for a one hour period, in the surrounding environment.

It is the contention of the Alberta Federation of Labour that in both instances (SO_2 and H_2S), the TLV for these two pollutants are set much too high. Because the acceptable level is above the level which is first detected through smell, a workman may be subjected to the undesirable odors caused by pollutants for eight hours a day, five days a week, for years on end. It is difficult to believe that continuous exposure to low levels of in-plant pollutants over a number of years will not have some adverse effects on the health of employees. It is suggested that more thorough and concentrated research be done to ensure the continued health of the employees who have been exposed to these pollutants over a long period of time.

LEGISLATION, REGULATIONS AND STANDARDS

According to Dr. Klemm's recent study submitted to the Environment Conservation Authority indicator tubes whose color changes relative to various H_2S and SO_2 levels are consulted after plant personnel detect by odor what to them seems an unusually strong smell of H_2S or SO_2.

Safety alarms which announce approach of a potentially explosive mixture of H_2S and air or hydrocarbon and air may be found in compressor buildings and around equipment capable of setting up static electric charges or generating sparks. Concentrations of H_2S or hydrocarbons which constitute near-explosive mixtures with air are well in excess of concentrations considered injurious to human health. This information would indicate that there are no continuous monitoring devices with automatic alarm systems set up to detect pollutants above the TLV's and to warn the employees in the surrounding area. If this is a fact, then we urge that such devices be set up immediately. It is also revealed in Dr. Klemm's report that there is no detection equipment on plant site outside the building which would confirm what concentration of harmful gases are present.

Through the fragmented information that we have available, it seems fairly obvious that a monitoring system in-plant, on-site and off-site, is very much in need of upgrading.

With regard to inspections, in the report of Dr. Klemm, there seems to be some conflicting information as to the number of field inspectors or staff that are on hand. In the first instance, on page 39 of the report, he points out that there are a number of inspectors at different points serving in different capacities in order to carry out field inspection in gas processing plants. On page 89, Dr. Klemm states that in Alberta there is only one inspector of occupational health and no legislation enabling him to enter company premises except at the invitation of the plant's operator or manager. It is safe to assess that if an inspector is going to enter premises only on such occasions, then the best interests of the employee are certainly not being respected.

Taking these two conflicting statements into consideration, we are not aware of what the situation is, but we suggest that adequate field inspectors be made available with authority to enter premises at any time and make the necessary inspections. Sufficient occupational health inspectors under the Board of Industrial Health are particularly essential to ensure that workmen are not exposed to conditions harmful to their well being. In order that a true perspective of the normal operations of a plant may be witnessed, we would suggest also that the inspectors refrain from giving the concerned operation advance warning of his conducting an inspection.

It is rather disturbing to see that the Energy Resources Conservation Board's responsibilities which apply to the oil and gas industries are funded equally by the provincial government and the oil and gas industry. It would seem to us that when an industry is providing funds for the inspection of its premises, then that industry will have some voice as to how these inspections are carried out. Such an arrangement may have a tendency of overlooking or minimizing potential hazards to a workman's health and safety. We would suggest that the Board's finances be derived wholly from the provincial government.

Health standards assumed for the employee differ considerably from those of the rest of the community. Indeed, TLV's of 10 and 5 ppm for H_2S and SO_2 respectively for an eight hour day, five days a week, seem to bear little relation to the ambient air quality standards for the province exclusive of the plants. As an ultimate standard, we would suggest that the working conditions inside the plant should adhere to the same standards that are enjoyed by the community off site. As a minimum, the TLV's must be reduced to a level at which the employees would not be

subjected to the continuous odors produced by the pollutants present.

EXTRACTION PROCESS AND DIVERSIFIED USES

At present there is a surplus of sulphur in Canada. Predictions are that the surplus will grow even greater in the very near future as markets and prices have become depressed. This should not be used as a reason to pollute our environment through excessive waste. No doubt, in the future, new markets will come into effect as a result of research into diversified uses of sulphur. At this moment, an experiment is being conducted at McGill University, Macdonald College, as to the feasibility of using rock sulphur for construction of homes. An article in Environment News, June, 1972, outlines the efforts of a Calgary-based research group which has developed a new process for removing sulphur compounds from natural gas with almost 100% efficiency. The technique operated so far only at the laboratory level was announced by Alberta Sulphur Research Limited, an industry-supported sulphur research group at the University of Calgary, Chemistry Department. It is our understanding that a U.S. based firm had presented a brief at a previous hearing outlining a formula capable of more efficient extraction than the present Claus system.

It is imperative that the present extraction system be made more efficient to reduce the waste of sulphur and the resultant harmful emissions into the environment. Directives should be given immediately from the Board to gas processing plants to improve the efficiency of their operations. Dr. Hyne, Research Director for Alberta Sulphur Research Limited, suggested that provincial and federal levels of government should provide some support to research as tangible evidence of their interest in environmental matters. This request seems like another instance of

companies looking for a handout from various levels of a government to finance a project that in our opinion is solely their responsibility.

Companies in the past have threatened closure of plants when faced with the prospects of higher operating costs. They are doing so now. No doubt they will continue to shed tears of poverty in the future. However, through past experience we have found that they continue to prosper and reap millions of dollars in profits despite their so-called insurmountable overhead.

ACCIDENT PREVENTION

Records of Workmen's Compensation Board attributing accidents and fatalities to H_2S indicate a great need for concern in this area. In the past five and one-half years, out of 337 reported accidents attributable to H_2S, there were * fifty fatalities. These are grim figures indeed, and the year-by-year breakdown indicates that the number of accidents and fatalities per year have remained fairly stable. These figures are not necessarily accurate as there may be instances where a worker is exposed to H_2S, recovers quickly, and may lose only a couple of hours of work. This type of accident is not usually reported. As the detailed reports remain in the confidential files of the Workmen's Compensation Board, employees continue to face the same hazards and the same prospects in the future.

We recommend most emphatically that it is time that concerned government departments took the necessary responsibility in a co-ordinated effort to reduce these statistics in the future. It is evident from the scant information we have available that upgrading in job-site training, inspections, and enforcement would greatly alleviate the grim statistics we are faced with today. Violations of regulations should be subject to

* An erratum to this statement was received from Mr. Kostiuk and has been attached to this submission as an appendix.

greater penalties in order to act as an effective deterrent.

A classic example is a recent headline in the Edmonton Journal which read, "Welding Too Close to Wellhead - Companies Fined $300". The article goes on to explain that the prosecutor said the maximum fine is $1,000 for the violation, but he asked the judge for the minimum punishment because it was a first offense and the companies involved seemed co-operative in restoring safe practices. The judge complied with the request. It is needless to say that such a situation could have very easily produced a fatality. Because of the grave potential hazard that exists in situations as the one mentioned above, prohibitive fines should be levied where infractions of regulations are found to take place.

THE NEED FOR RESEARCH

It is well to hold hearings, to determine what is happening to our environment and life therein supposedly as a result of the operation of sulphur extraction gas plants. Such a step must be considered as an essential phase of research and the Department of the Environment must be complimented on their action. It is, however, only a segment of the broad field that must be covered in order to ensure the future health of our on-site worker, and our off-site community, the fertility of our soil, the health of our forests and the wildlife therein, and the purity of our lakes and rivers together with the life they sustain.

There is apparent lack of detailed technical data to substantiate apparent harmful effects of sulphur extraction gas plants. The Alberta Federation of Labour must strongly submit that the government, through its inter-related departments concerned with the environment, research the necessary information, set up standards complementing the research,

and make provisions for a monitoring system that will ensure that such standards are adhered to. In the meantime, existing air quality standards and TLV's must be upgraded immediately in order to remove the possibility of doing irreparable damage to our environment and ensuring the health of the workmen. The grim testimony submitted by individuals at previous hearings must surely attest the need of such immediate action.

SUMMARY

The Alberta Federation of Labour strongly urges the implementation of the following:

1. thorough research on the long-term effects to employees who have been exposed to low concentrations of pollutants over a long period of time;
2. upgrading of in-plant, on-site and off-site monitoring systems;
3. sufficient qualified field inspectors with authority to enter premises and make necessary inspections;
4. increased staff of qualified occupational health inspectors under the Board of Industrial Health jurisdiction;
5. no advance notice of intent to inspect premises;
6. funding the Energy Resources Conservation Board wholly by the provincial government;
7. standards for working conditions in-plant, as an ultimate, should be the same as off-site. As a minimum, in-plant TLV's should be reduced to a level below the odor threshold.
8. upgrade the efficiency of the sulphur extraction process;
9. research based on efficient extraction processes to be funded wholly by industry;
10. a co-ordinated effort by concerned governmnnt departments to reduce the accident rate by upgrading job-site training and inspections;
11. more severe penalties for violation of regulations;
12. a thorough research program designed to cover all harmful aspects of sulphur extraction plants.

Respectfully submitted,

ALBERTA FEDERATION OF LABOUR

Alberta Federation of Labour

CHARTERED BY

Canadian Labour Congress

ROY H. JAMHA
PRESIDENT

EUGENE A. MITCHEL
EXECUTIVE SECRETARY

#306, 11010 - 142ND STREET
EDMONTON, ALBERTA T5N 2R1
TELEPHONE 454-6307

October 25, 1972

Dr. W. R. Trost, Chairman
Environment Conservation Authority
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

Dear Sir;

I wish to point out an error made in our recent submission to the Public Hearings respecting environmental effects of the operation of sulphur extraction gas plants.

On page 7 of the brief under the heading "Accident Prevention", the second sentence dealing with the number of fatalities read:

> "In the past five and one-half years, out of 337 reported accidents attributable to H_2S, there were <u>fifty</u> fatalities."

This statement should have read:

> "In the past five and one-half years, out of 337 reported accidents attributable to H_2S, there were <u>fifteen</u> fatalities."

I would like to extend my sincere apologies for this error. I certainly regret such a mistake was made.

Yours truly,

H Kostiuk

Harry Kostiuk
Assistant Executive Secretary

HK*km
OPEIU#458
c.c. Hon. B. Hohol, Minister of Labour

QUESTIONING BY THE AUTHORITY

DR. S.B. SMITH

Have you or has the Federation any data on what concentrations of SO_2 and H_2S workers actually endure in the plants?

MR. H. KOSTIUK

No, but we do have information that they are in very many instances subjected to the uncomfortable odours that come with the presence of these two gases.

DR. S.B. SMITH

Has the A.F.L. or any of the locals asked companies or governments to set up government-industry-labour inter-related research projects to get at the question of concentrations in the plant? Have you made approaches to government and companies to set up these kinds of evaluations?

MR. H. KOSTIUK

No, we haven't to my knowledge.

DR. S.B. SMITH

Do you plan to?

MR. H. KOSTIUK

Perhaps by making our wishes known now, in the future we will carry out these studies.

DR. S.B. SMITH

Do you think it would be productive if the A.F.L. made such an approach directly to industry and government for this kind of evaluation?

MR. H. KOSTIUK

We can only do this through our affiliated unions; but then we do make the direct representations to government.

DR. W.R. TROST

Do you want to elaborate on your figures a little bit?

MR. H. KOSTIUK

As far as reported accidents are concerned in regard to H_2S, not specifically in sulphur extraction plants, they are very hard to get from the Workmen's Compensation Board, or any other body that we are familiar with; because, it seems that the oil companies are very touchy about any publication of any instances that may happen in any of the plants. It is really very hard to find out exactly what is going on in the plants aside from workers. This information is hard to come by because these workers are reluctant to come forward and report incidents which may be harmful because of possible repercussions from the company. It might be well to ask the Conservation Authority whether it would be prepared to meet with such individuals to get specific instances as to what is going on within the plant; with the assurance that there will be no repercussions on them. It seems that by the reluctance that has been exemplified in the past, that these people are reluctant to give any specific instances because of possible repercussions.

DR. W.R. TROST

Had you any actual evidence or cases to cite in this matter, Mr. Kostiuk?

MR. H. KOSTIUK

Not personally I haven't; but it's just that the information was given to us, not personal cases that I can cite.

DR. W.R. TROST

Does the union take any part in respect to job training programs related to environment protection or health on the one hand and the formulation of health standards in in-plant situations?

MR. H. KOSTIUK

There are in some plants safety and health committees set up in co-ordination with the management to look after the standards or regulations that are in the plant. They are working under some stress because they have committees set up, in some instances in name only with really no authority to act in any specific instances. If complaints arise, is there a complaint handling process in the plant, and if so, does the union participate in it, or has the union a separate complaint to process? Specifically I cannot answer this question.

MR. R. BASKIN

If a union is in a plant, when a complaint occurs it is handled through the normal grievance procedure. In places where there is a safety and health committee, one member of the safety and health committee is involved through the grievance procedure. I am not aware of the method of handling where no union is in existence.

DR. W.R. TROST

Is the suggestion that this grievance procedure isn't all altogether satisfactory?

MR. H. KOSTIUK

The grievance procedure is generally satisfactory for dealing with something that is specific and something that is contained in the Collective Bargaining Agreement. I don't think the Grievance Procedure is particularly designed to deal with the health and safety matters that are normal, day to day reactions of individuals. It should logically be for settlements of important issues between management and the employees. If you don't have a health and safety committee, some of these complaints go on and on and multiply into something much larger than they really are. If there is a direct communication which is almost immediate, the facts can be known. In many cases, management can get to the facts faster if they know who they have to contact. The workers are sometimes less reluctant to contact their committee chairman than they would be to contact their plant foreman, their process foreman or the plant Superintendent. In many cases the management above the plant Superintendent are very noticeably not in attendance at the plant until there is a major problem, so you have to deal with the local supervision.

UNIFARM SUBMISSION

to the

ENVIRONMENT CONSERVATION AUTHORITY HEARINGS

DEALING WITH

SULPHUR EMISSIONS

FROM GAS PLANTS

Presented by: J. R. McFall

EDMONTON, ALBERTA

October 19, 1972

Mr. Chairman:

Unifarm appreciates the fact that the Environment Conservation Authority has organized this series of hearings to try and determine the effect of sulphur compounds on the environment generally and on the health and welfare of society in particular.

Sulphur, like plants, insects, wild life and other features related to our ecology, has a beneficial role. When these features appear in excess or are misplaced they become weeds, pests, inconveniences and hazards. It is recognized that sulphur is one of the essential elements required for plant growth. This is particularly true in the gray wooded areas where sulphur is deficient. The application of sulphur is also recommended for legume-grass hay, and pastures for all soils of Alberta. The recent addition of a soil sulphate test by the Alberta Soil and Feed Testing laboratory will be helpful in determining the amount of sulphur required or amounts in surplus. The proper balance of sulphur in soils can be very critical. There is some evidence that selenium deficiency in fodder may be related to soils fertilized with sulphur compounds which may in turn be related to White Muscle disease effecting cattle in some gray wooded areas.

We are not in a position to discuss these aspects but suggest that while sulphur is essential it can also be damaging to plant and animal growth.

Unifarm has sought opinions and observation of farmers in four particular areas of the province, namely, Fox Creek - Blueridge, Rimbey, Calgary - Red Deer and Pincher Creek. Names of Unifarm members were selected at random from our mailing list from the above areas. A total of 332 questionnaires were mailed. Sixty three reports were returned, approximately 20%.

From the reports received it is very evident that distance and direction from plants or wells had a definite relationship to inconveniences experienced. For example, in the Calgary-Red Deer area out of 22 reports from within a 10 mile radius, 10 reported gas odours and 11 reported no odours. Those reporting from outside the 10 mile radius, 4 reported gas fumes and 9 reported no odour.

With regard to sulphur dust, within 10 miles, 4 reported observation of sulphur dust. Outside the 10 mile radius there was no report of dust. A number reported evidence of sulphur on the edges of water pools following rain fall.

The reports did not indicate any noticeable soil deterioration or ill effects on crops. On the other hand, there was no positive effects.

The one area where opinions were strong and consistent in all reports related to corrosion of wire fences and farm machinery and effect on paint. In this area distance and direction seemed to have less effect.

Again referring to Calgary-Red Deer area, under 10 miles, 17 out of 20 reported fence corrosion. Outside the 10 mile area, 4 out of 12 reported fence corrosion. With regard to other areas corrosion damage was reported on a similar ratio.

It has been estimated and reported that in 1971 the total emission of sulphur as sulphur dioxide, amounted to 450 long ton per day. Other estimates* are 847 long tons per day for the area generally south of Edmonton.

These estimates may well be valid but they do not provide us with the concentration in particular areas, nor do they indicate the area that will be subject to fallout or rain out.

The effect of sulphur on land, crops, livestock and human health as reported does not give sufficient evidence to indicate any particular effect. On the other hand the reports indicate that sulphur gas does cause some inconvenience and annoyance, particularly close to the plants and down wind from them. The corrosive effect on wire fences, farm machinery and painted buildings appears clear cut. The replies indicate that increased corrosion covers a much wider area and is of concern to many farmers.

In making this submission we appreciate the fact that we cannot be precise in our statements. However, we feel that there is enough evidence to indicate a sulphur pollution problem and that every precaution must be maintained to keep this gas emission within our clean air standards.

To achieve this Unifarm urges that strict regulations be maintained and where necessary research be under taken to help achieve the desired results.

We are attaching a summary of questionnaire replies related to sulphur dust - sulphur dust and corrosion, also some pertinent comments.

* Dr. Peter Summers,
Research Council of Alberta.

Respectfully submitted,

Unifarm.

October 19, 1972.

Comments regarding Sulphur Emissions by persons replying to Unifarm Questionnaire.

Comments from Calgary-Red Deer area - 10 or more miles from plants

George Belich - R.R. 2, Red Deer. "We are at quite a distance from the nearest plant but have been puzzled by the fact that during the past four years (3-4) our fences have been rusting as I have never before experienced in forty years. This includes new wire which was strung in 1963."

O. D. Davis, R. R. 1, Innisfail, 15 miles S.E. plant. "When these plants first started to operate we used to get a terrible smell when the wind was in the right direction. We hardly ever get a smell from the plants anymore."

Less than 10 miles from plant

Garry Anderson, R. R. 1, Bowden, 3 miles S.W. "The rusting and corrosion to metal is almost unbelievable. A bare piece of steel, e.g. jackknife blade, if touched with a drop of water will show a rust spot within 20 minutes, honest!!

H. W. Anderson, Box 178, Bowden, ½mile S.W. "I am most positive that we are damaged by the pollution in the area here. All or most all metals, wire, nails and especially paint, really show the effects of the pollution, and I am sure our respiratory systems must suffer as well."

Box 311, Carstairs - "Living 1½ miles of Carstairs town and after a long dry spell the first rain fall of the season brought down yellow coloring on edge of puddles, very noticeable at the time. This happened in the first part of June. Also from a gas well in our district very sickening smells are evident often. This well marked poisonous."

B. Christoffersen, R. R. 1, Didsbury, 5 miles N.W. "Sulphur deposits appear around water puddles after rains. In some weather conditions foul smell is evident from a well in S. W. direction, 1½ miles away."

G. K. Burns - Didsbury, 6 miles N. "We have added sulphur through fertilizer with noticeable benefit, over the past 6 - 8 years but are now discontinuing the practice as we find evidence through white muscle disease that sulphur level is high enough."

Lloyd H. Chandler, R. R. 1, Didsbury, 5 miles S.E. "We have been dissatisfied with analyses of water, sludge, and organs of a calf that we had sent to the Oil and Gas Conservation Board at Red Deer, and/or Edmonton laboratories. We were refused a report in two cases. The calf organs were sent only to Edmonton not to Red Deer.

It is almost impossible to limit our complaints to sulphur in the air and streams for other serious pollution is so closely related. The company had a pipe installed on a shoulder of the road as well as several culverts for the purpose of fraining waste and oily water into a ditch along plant frontage. I have pictures of these. We called in the press and these installations were later removed,although the manager disclaimed any responsibility.

Marked land deterioration from pipelines and related activities, also from a 16½ mile railroad installed to haul sulphur from the plant to north of Didsbury is evident. A 9 acre corner of our best land was expropriated for the latter and is now out of agricultural use. This, and the infestation

Comments.....

of thistles and noxious weeds in places inaccessible to cultivation and even spray such as tree windrows, fencelines and corners and groves, are so related to the production of sulphur that I cannot separate them into separate categories. Along with this is the absurdity of the so-called monitoring devices.

And this spring Shell Oil took considerable land out of agricultural use to create a lake supplied from the Little Red Deer River and we are apprehensive of its effect on the river."

2. Blue Ridge Area

Joe Tschedged, White Court, 5 miles S.E. "We receive obnoxious smell when wind is from the N.W. We have observed rapid corrosion on fence wire and machinery in the last few years. Prior to this we have observed fence wire in use for 40 to 50 years showing signs of corrosion only where it was burned by bush fires. We feel that some element in the air must be causing this damage."

3. Pincher Creek Area

W. E. Bird, Box 58, Pincher Creek, 7 miles N.E. "Corrosion on wire fences and machinery is terrible and fences will have to be replaced soon as a result of fumes. Macninery doesn't last long as the corrosion east right into the steel. We think these fumes do have some effect on animals but it is hard to determine. We would like to know how big a health hazard we are living in and we haven't been able to find out the truth. Perhaps if we knew the real truth we would be long gone."

Pincher Creek, 4 miles S.W. " In the adjacent areas to the gas plants the trees this year have no green leaves and appear to be dead. We are wondering if the acidity in the air causes this? As we live near the gas plants we notice that at dusk and through the night the flares at both plants have very large burning flares from their stacks. They are not this way in the day time. When testing helicopters were taking atmospheric samples around the gas plants this spring the flares and the smoke stacks were not flaring. But as soon as the helicopters were gone again there were big burning flares."

4. Rimbey Area

H. Bernes, Bluffton, 10 Miles N.W. "It appears that I am not getting the crop yields I should and many farmers in this area are having white muscle trouble in very young calves which is caused by a lack of Vitamin E and selinium in soil and feed. I feel that there should be more research and fact finding done along this line."

John T. Burns, R. R. 2 Bluffton, "Possibly some of the corrosion on fence wire is due to poor quality (less protective cover) as some relatively new wire seems rather more effected than some older wire."

Summary Report on Questionnaire regarding Sulphur Emissions

1. Distance from plant.

(a) Calgary-Red Deer	- 22 less than 10 miles, average 4 miles	
	- 13 more than 10 miles, average 15 miles	
(b) Rimbey	- 12 reports - 4 to 25 miles, average 10	
(c) Pincher Creek	- 10 reports - 5 less than 10 miles, average 3.5	
	- 5 over 10 miles, average 25 miles	
(d) Blue Ridge	- 4 reports 2 to 15 miles.	

2. Do you experience gasses?

(a) Calgary-Red Deer	under 10 miles	Yes 10	No 11
	over 10 miles	Yes 4	No 9
(b) Rimbey		Yes 6	No 7
(c) Pincher Creek	5 long distance reports all negative		
(d) Blue Ridge		Yes 2	No 2

3. Evidence of Sulphur Dust

(a) Calgary-Red Deer	under 10 miles	Yes 4	No 14
	over 10 miles	--	No 12
(b) Rimbey		Yes 4	No 5
(c) Pincher Creek		Yes 3	No 1
(d) Blue Ridge		Yes 1	No 3

4. Evidence of sulphur in streams or on water pools.

(a) Calgary-Red Deer		Yes 2	No 25
(b) Pincher Creek		Yes 3	No 1

5. Corrosion

(a) Calgary-Red Deer	under 10 miles	Yes 17	No 3
	over 10 miles	Yes 4	No 8
(b) Rimbey		Yes 8	No 3
(c) Pincher Creek		Yes 5	No -
(d) Blue Ridge		Yes 2	No 2
Totals		Yes 36	16

6. Machinery

(a) Calgary-Red Deer	under 10 miles	Yes 15	No 4
	over 10 miles	Yes 2	No 7
(b) Rimbey		Yes 8	No 3
(c) Pincher Creek		Yes 4	No -
(d) Blue Ridge		Yes 1	No 2
	Total	30	16

Paint

(a) Calgary-Red Deer	under 10 miles	Yes 8	No 8
	over 10 miles	Yes -	No 9
(b) Rimbey		Yes 5	No 5
(c) Pincher Creek		Yes 4	-
(d) Blue Ridge		Yes -	No 2
	Total	17	24

"The original questionnaire replies are held in the Information Center, Environment Conservation Authority, 9912 - 107 Street, Edmonton, Alberta."

QUESTIONING BY THE AUTHORITY

DR. W.R. TROST

You have a summary report on the questionnaire. Do you want to comment on that?

MR. J.R. MCFALL

We attempted to get the distance and direction from the wells where these people resided. For example, in the Calgary - Red Deer area; twenty -two reports came from less than ten miles, an average of four miles. There were thirteen reports in that area that were over ten miles, about an average of fifteen. At Rimbey we had twelve reports and they averaged from four to twenty-five miles; Pincher Creek, ten reports, five less than ten miles and five over ten miles. At Blue Ridge, we only had four reports, and they were from two to fifteen miles.

Now with regard to the experiencing of gas fumes; in the Calgary - Red Deer area, under the ten miles ten reported that they had experienced this gas, and eleven, no. Over the ten miles, four reported experiences of gases or odours, and eleven no. At Rimbey; six said yes, and seven said no. Pincher Creek was just five long distance reports, and they were all negative. From Blue Ridge there were two for yes and two for no.

On the evidence of sulphur dust, under the ten miles from Calgary - Red Deer four reported they experienced sulphur dust, fourteen no. Over the ten miles, there was no noted sulphur dust and twelve said they didn't experience it. At Rimbey four said yes, five said no. On evidence of sulphur in streams or on water pools, Calgary - Red Deer two out of twenty-five experienced that; and Pincher Creek, three experienced sulphur in the streams against one that said no.

On corrosion: under the ten miles, seventeen experienced corrosion, and three said no. Over the ten miles, four experienced corrosion, and eight said no. At Rimbey, eight said yes, and three said no; Pincher Creek, five said yes, and there was no comment on the other part; Blue Ridge, two said yes and two said no.

On machinery, it was very similar. Under ten miles in the Calgary - Red Deer area; fifteen yes, fourteen no; over the ten miles, two yes and seven

no. Rimbey was eight yes, and three no. Pincher Creek was four yes, and Blue Ridge was yes one, and two no. The paint problem was very similar; Calgary - Red Deer area, yes eight, eight no. Over ten miles, nine said no evidence. At Rimbey it was five yes and five no. Pincher Creek was four yes, and Blue Ridge had no effects.

DR. W.R. TROST

Did you ask in your questionnaire whether there had been any change in the last year or so, as against say ten years ago in farmers' experiences of these matters?

MR. J.R. MCFALL

We had a question,"If sulphur pollution is or has been experienced, when was it first experienced?" Quite a number of the reports went back a number of years, and generally you would find that it tapered off; but some were not too specific in their answers.

DR. S.B. SMITH

In the field of agriculture generally, questionnaires are very common and here we have only a 20% response. My impression at looking at questionnaires over many years is you normally expect to get about one-third in replies. Does this reflect the independence of farmers?

MR. J.R. MCFALL

It's too low to satisfy me, but I think generally that you will find whether it's rural or urban that twenty is not too bad.

BRIEF ON ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS

Submitted by

THE FEDERATION OF ALBERTA NATURALISTS

Presented by

DR. J. POWELL

The Federation of Alberta Naturalists recognizes that large quantities of sulphur are contained in the natural gas reserves of Alberta; that ways must be found to extract this sulphur to clean the gas and for the marketing of pure sulphur or of sulphur compounds; that the Petroleum Gas Industry in Alberta has been making serious attempts to reduce environmental pollution; and that the Government of the Province has gradually been tightening regulations to ensure that pollution is kept to a minimum.

The Federation also recognizes that serious environmental damage results from air and water pollution by sulphur and sulphur compounds escaping in various forms from Gas Extraction Plants. It feels that numerous instances of damage have been well documented and that the Provincial Government, the Industry, and the public, has learned from these experiences and that conditions continue to improve. The Federation is particularly concerned, however, in regard to a number of subjects, especially as there appears to be a trend for the development of more and larger extraction facilities.

Firstly, we believe that industry and government do not know nearly enough about the effects of sulphur pollution on plants, animals, and on inanimate objects. We urge that the Provincial Government encourage further research in this area. We need to know exactly what happens, so that sensible legal and precautionary limits can be established.

Secondly, we feel that the monitoring of the amount of air and water pollution has been too superficial in the past. We know that monitoring systems utilizing chemical devices and biological indicators can be set up reasonably inexpensively. We feel that such systems should be put into operation in association with most of the already existing plants. We also urge that tree-dwelling lichens be used as biological indicators whenever

possible. Their use in Alberta has been very spotty to date, and at the present we are aware of their use only in connection with the Ram River development by Aquitaine [cf. Oil Week 23(29):22]. Lichens not only act as indicators of the amount of pollution but also indicate its extent. Publications by F. LeBlanc and others describe the principles involved with the use of lichens as biological monitors and outline methods of application. These should be required reading for all researchers, planners, and legislators. A list of pertinent references is attached.

Thirdly, we urge that the Provincial Government encourage research into the discovery of practical methods whereby environmental pollution from Sulphur Extraction Plants can be kept to a minimum. This should involve study in two directions: (1) to find "tighter" methods of processing so that smaller amounts of sulphur compounds are given off as waste, and (2) to come up with better methods, such as electrostatic precipitators, by which to remove gaseous, solid, and liquid effluents.

Fourthly, we urge that the Provincial Government carry out a more thorough policing of the regulations which are now in effect. Most operators are dependable and conscientious but, as in all spheres of life, society must be protected from carelessness and from a small minority of amoral individuals.

SELECTED REFERENCES CONCERNING LICHENS AND AIR POLLUTION

Brodo, I.M. 1966. Lichen growth and cities: a study on Long Island, New York. Bryologist 69: 427-449.

Brodo, I.M. 1961. Transplant experiments with corticolous lichens using a new technique. Ecology 42: 838-841.

Coker, P.D. 1967. The effects of sulphur dioxide pollution on bark epiphytes. Trans. Brit. Bryol. Soc. 5: 341-347.

De Sloover, J. 1968. Pollutions atmosphériques et tolérance specifique chez les lichens. Bull. Soc. Bot. France, Mém. 1968: 205-217.

De Sloover, J. & F. LeBlanc. 1968. Mapping of atmospheric pollution on the basis of lichen sensitivity. Pp. 42-56, in R. Misra & B. Gopal (eds.) "Proceedings of the Symposium in Recent Advances in Tropical Ecology". Internat. Soc. Trop. Ecol., Banares Hindu Univ., Varansi.

De Sloover, J. & F. LeBlanc. 1970. Pollutions atmosphériques et fertilité chez les mousses et chez les lichens épiphytiques. Bull. Acad. Sci. Lorraines Sci. 9: 82-90.

Dreisinger, B.R. & P.C. McGovern. 1970. Monitoring atmospheric sulphur dioxide and correlating its effects on crops and forests in the Sudbury area. In Proceedings of the Impact of air pollution on vegetation conference. Toronto.

Gilbert, O.L. 1965. Lichens as indicators of air pollution in the Tyne Valley. Pp. 35-47, in "Ecology and the Industrial Society". Blackwell Sci. Publ., Oxford.

Gilbert, O.L. 1970. A biological scale for the estimation of sulphur dioxide pollution. New Phytol. 69: 629-634.

Hawksworth, D.L. & F. Rose. 1970. Qualitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. Nature (London) 227: 145-148.

LeBlanc, F. 1961. Influence de l'atmosphere polluées des grandes agglomerations urbaines sur les epiphytes corticoles. Rev. Canad. Biol. 20: 823-827.

LeBlanc, F. & J. De Sloover. 1970. Relation between industrialization and the distribution and growth of epiphytic lichens and mosses in Montreal. Can. J. Botany 48: 1485-1496.

LeBlanc, F. & D.N. Rao. 1966. Réaction de quelques lichens et mousses épiphytique à l'anhydride sulfureus dans la région de Sudbury, Ontario Bryologist 69: 338-346.

LeBlanc, F., D.N. Rao & G. Comeau. 1972. Indices of atmospheric purity and fluoride pollution pattern in Arvida, Quebec. Can. J. Botany 50: 991-998.

LeBlanc, F., D.N. Rao & G. Comeau. 1972. The epiphytic vegetation of *Populus balsamifera* and its significance as an air pollution indicator in Sudbury, Ontario. Can. J. Botany 50: 519-528.

Pearson, L. & E. Skye. 1965. Air pollution affects pattern of photosynthesis in *Parmelia sulcata*, a corticolous lichen. Science 148: 1600-1602.

Rao, D.N. & F. LeBlanc. 1966. Effects of sulphur dioxide on the lichen alga, with special reference to chlorophyll. Bryologist 69: 69-75.

Rao, D.N. & F. LeBlanc. 1967. Influence of an iron-sintering plant on corticolous epiphytes in Wawa, Ontario. Bryologist 70: 141-157.

Skye, E. 1965. Botanical indication of air pollution. Pp. 281-284, *in* "The Plant Cover of Sweden". Acta Phytogeogr. Suecica 50.

Skye, E. 1968. Lichens and air pollution. A study of cryptogamic epiphytes and environment in the Stockholm region. Acat Phytogeogr. Suecica 52: 1-123.

Tallis, J.H. 1964. Lichens and atmospheric pollution. Adv. Sci. 31(91): 250-252.

QUESTIONING BY THE AUTHORITY

DR. W. R. TROST

Dr. Powell, could you briefly summarize the advantages that lichen monitoring might have as against other methods.

DR. J. POWELL

I am not a lichenologist myself but lichens are very slow growing and are very long lived and therefore they are good indicators. They are also very sensitive to any pollution that exists in the area.

DR. S. B. SMITH

Dr. Powell, is the Federation a federation of natural history clubs? Could you tell the Hearing the composition and how many people it represents?

DR. J. POWELL

It is a federation of six natural history clubs in the Province. The Alberta Natural History Society centered in Red Deer, the Calgary Field Naturalists Society, the Bow Valley Naturalists centered in Banff, the Edmonton Bird Club, the Edmonton Natural History Club and the Lethbridge Natural History Society. Each of these clubs elects two delegates or two directors to the Federation of Alberta Naturalists which was formed in 1970. We also have certain appointed directors on the Board of Directors. Besides the membership of these co-operation members which amounts to about 1,000, we also have individual members from throughout the Province and outside. Altogether we have a total individual membership/associate membership of about 1200.

DR. S. B. SMITH

Was this paper written by a biologist here in the University of Alberta?

DR. J. POWELL

No. The University of Calgary.

DR. S. B. SMITH

Would he be available to answer more particular questions?

DR. J. POWELL

Yes, also the three people that had the main influence in this are the biologist at the University of Calgary and two people from the oil industry. They are all directors of the Federation.

MR. W. A. FLOOK

You indicate that you are aware of systems utilizing chemical devices which can be set up reasonably extensively. Would you like to elaborate a little bit on that. What type of instruments are you thinking of? I was wondering perhaps if you would indicate whether - what they had in mind were such things as sulphation cylinders or something a little more sophisticated.

DR. J. POWELL

No, I can't.

Environment Canada | Environnement Canada

Environmental Protection | Protection de l'Environnement
257 Federal Public Building
Edmonton, Alberta T5K 1E7

October 16, 1972

Your file Votre référence

Our file Notre référence 81 - 2

Environment Conservation Authority
Workmen's Compensation Building
9912 - 107 Street
EDMONTON, Alberta T5K 1G5

Dear Sirs:

Re: Environmental Quality Control for Natural Gas Processing Plants

Environment Canada appreciates this opportunity to contribute a Brief on the above subject to your Public Hearings. Preparation of the Brief was coordinated by the Environmental Protection Service, Northwest Region, Edmonton and our Ottawa headquarters. Inputs and reviews were also provided by: Atmospheric Environment Service, Edmonton; Canadian Forestry Service, Edmonton; and the Environmental Health Directorate of the Department of National Health and Welfare, Ottawa.

Should the Alberta government wish to discuss specific questions raised in the Brief or require further information, we would welcome future discussions on the subject of environmental quality control for gas processing facilities.

Yours very truly,

H Douglas Johnston

H. D. Johnston
Regional Director

/dmf

cc: Dr. H. M. Etter, EPS, Edmonton

TABLE OF CONTENTS

ABSTRACT

There is a growing volume of evidence that the release of sulphur gases to the atmosphere is having far reaching effects. The magnitude and impact of these changes are unknown but they could become of vital concern to mankind.

Locally, even low concentrations of sulphur oxides in combination with particulate matter adversely affect the young, the old and the infirm. The natural process of removal of sulphur oxides and dust from air is found to result in the formation and precipitation of strongly acidic substances which can adversely affect vegetation, materials and soil.

All these effects have been amply documented and the brief therefore does not repeat details available elsewhere.

For the above reasons, it is prudent to take whatever steps are readily available to protect the environment and in the absence of reliable information on the ability of the atmosphere to disperse pollutants harmlessly, the Government of Canada has embraced both the resource management and the best practical means philosophies in its strategies. These strategies have led to the statement of proposed maximum desirable, and maximum allowable objectives for sulphur oxides.

It is the hope of the Government of Canada that the proposed desirable levels of sulphur dioxide will be a basis for improved sulphur recovery processes and that existing plants will be upgraded at least to the proposed maximum acceptable level.

A. WORLD AND CANADIAN POSITION ON POLLUTION CONTROL

In June of this year, a world conference was held in Stockholm, Sweden, under the aegis of the United Nations to consider the impact of pollution on the earth as a whole and to devise procedures for international cooperation in pollution control. Canada played a major role in the preparations for this Conference, and endorsed far-reaching resolutions to reduce substantially the burden of pollutants, including emissions to the atmosphere. We welcome, therefore, this opportunity to confirm the goals to which we have subscribed on your behalf at Stockholm and to work with Alberta to promote a level of emission control consistent with that for other Canadian provinces.

The increase in per capita use of energy and in production of pollutants, together with the explosive increase in the population of the earth has led to the realization that traditional disposal mechanisms can become overloaded and far reaching changes in the environment could result.

Possible irreversible changes in the earth's atmosphere could occur. One such change could be in the net-radiation received from the sun: due to increasing the CO_2 content of the atmosphere ("Greenhouse Effect"), increasing the particulate content of the atmosphere,

or destroying the ozone layer which filters out the short ultra violet energy. Another change could be oxygen content of the atmosphere: due to interference in biological processes with pesticides, alterations in the diversity and stability of the earth's flora and fauna, and combination of fossil carbon.

While the impact and magnitude of these changes are yet unknown, it is only prudent to take whatever steps are readily available to protect the environment. Therefore, while Canada actively supports the collection of data to evaluate man's effects on the environment, we recognize that we are not yet in a position to decide exactly how much pollution can be safely discharged into the environment, and we therefore embrace the "Best Practical Means" and "Resource Management" philosophies in our strategies.

B. FEDERAL STRATEGIES OF POLLUTION CONTROL

There are two distinct strategies for controlling pollution based on the "Best Practical Means" and the "Resource Management" concepts. The "Best Practical Means" approach to air pollution, simply stated, is the use of the best available technology (including economic considerations) to prevent all emissions at their source without regard to ambient air quality surrounding the source. In contrast, the "Air Resource Management" approach stresses that ambient air quality is the basic element in all control programmes. The first approach does not allow emission of any pollutant which can be economically collected and removed. The Resource Management approach permits the release of pollutants up to the assimilative capacity of the environment. The latter is the more economical since the capacity of the environment is exploited. However, there is no easy method of allocating environmental capacity amongst several industries or to provide for new-comers. In addition, the assimilative capacity of the atmosphere is not known with accuracy. Of course, even the best practical means may not be sufficient to meet the limitations of environmental capacity, and as it becomes more accurately defined, improved techniques may have to be sought. However, the sole use of air resource management and ambient air quality objectives is seen by many, including the Federal Government, as entailing the deliberate degradation of air quality which at present

is superior to the ambient air quality in other locations. The best practical means strategy can help to prevent this degradation.

In view of the Federal Government, an optimum program combines the advantages of both the best practicable technology <u>and</u> the air resource management strategies. Such a program includes:

- the control of new stationary sources by the best practicable technology;
- the control of existing stationary sources, within a negotiated period of time, by the best practicable technology; and
- the control of urban and mobile air pollution sources by the air resource management approach.

The Federal Minister of the Environment has made it clear that control at the source is our basic aim - "we are reluctant to rely upon nature's 'assimilative capacities' because we simply do not know enough about the science of ecology to predict the results". Air pollution control is therefore <u>Preventive Management</u>.

Thus, at the Federal level we see great merit in the best practicable technology viewpoint. At the same time, we recognize that it does not solve all our problems, and thus one of the sections of our Clean Air Act is related directly to the Air Resource Management concept. This section of the Act allows the Government to prescribe National Air Quality Objectives.

The Minister has proposed objectives for five major air pollutants - sulphur dioxide, particulate matter, carbon monoxide, photochemical oxidants and hydrocarbons - and we are working on a sixth, nitrogen oxides. These objectives were recommended by a committee of Federal and Provincial experts after an examination of the scientific data describing their effects on various receptors. These specific objectives are discussed further in a later section of this brief.

C. EFFECTS OF SULPHUR COMPOUNDS ON MAN AND OTHER ANIMALS

Sulphur dioxide has been recognized as a toxic industrial gas for more than 100 years and its effects on man in a relatively pure state are well understood. The industrial Maximum Allowable Concentration for workers exposed for 40 hours per week is 5 ppm and there is little evidence that workers have suffered as a result of this limit. For the most part the effects of the oxides of sulphur on health are related to irritation of the respiratory system. Such injury may be temporary or permanent.

Laboratory studies show that sulphur dioxide can produce bronchoconstriction in experimental animals such as the guinea pig, the dog, and the cat. Dose-response curves have been established for the guinea pig, the most susceptible laboratory animal studied to date. They relate the concentration of sulphur dioxide to the observed increase in pulmonary flow resistance produced by 1-hour exposures. Slight increases in resistance are detectable at 0.16 ppm (460 $\mu g/m^3$) but the changes are readily reversed.

The response of bronchoconstriction in man has been assessed in terms of a slight increase in airway resistance on administering SO_2. Normal individuals, exposed to

sulphur dioxide via the mouth often exhibit small changes in airway resistance, which are insufficient to produce any respiratory symptons. The effects may be even smaller when the subject breathes through his nose. As in animals, sulphuric acid which may be produced by oxidation of sulphur dioxide is a much more potent irritant in man than is sulphur dioxide.

Laboratory observations of respiratory irritations suggest that most individuals will show some response to sulphur dioxide when exposed for 30 minutes to concentrations of 5 ppm (about 14 mg/m^3) and above. Exposure of certain sensitive individuals to 1 ppm to 2 ppm (about 3 mg/m^3 to 6 mg/m^3) produces changes, whose medical significance has not yet been fully defined.

Epidemiological studies of episodes occurring in London suggest that a rise in the daily death rate occurred when the concentrations of sulphur dioxide rose abruptly to levels at or about 715 $\mu g/m^3$ (0.25 ppm) (as measured by the hydrogen peroxide titrimetric method) in the presence of smoke at 750 $\mu g/m^3$. A more distinct rise in deaths has been noted generally when sulphur dioxide exceeded 1000 $\mu g/m^3$ (0.35 ppm) for one day, and particulate matter reached about 1200 $\mu g/m^3$ (measured by the British reflectometer

method). Daily concentrations of sulphur dioxide in excess of 1500 $\mu g/m^3$ for one day (0.52 ppm) in conjunction with levels of suspended particles exceeding 2000 $\mu g/m^3$ appear to have been associated with an increase in the death rate of 20 percent or more over base line levels.

A major British study has found an association between mortality from bronchitis and lung cancer and levels of air pollution after taking into consideration differences in age, smoking habits, social class, and occupational exposure. The sulphur dioxide values for a year averaged 116 $\mu g/m^3$ (0.040 ppm) for the polluted area, and 75 $\mu g/m^3$ (0.026 ppm) for the cleaner area. Corresponding smoke values were 160 $\mu g/m^3$ and 80 $\mu g/m^3$, respectively.

These data indicate that in polluted air masses, even relatively low SO_2 levels may not be tolerated. The response to sulphur dioxide is obviously complex and is strongly influenced by other pollutants such as aerosols formed in polluted air masses. It must be remembered that pure SO_2 measured in the ambient atmosphere of large cities (as in epidemiological studies) co-exists with a wide range of other pollutants, gases, organic aerosols, carbonaceous dusts and metal oxides. A synergistic effect

between SO_2 and other pollutants has been proven, although the mechanisms of the synergistic agent(s) is as yet unknown, and much difficult research remains to be done in this field.

No attempt will be made here to deal exhaustively with this complex problem since detailed Criteria Documents have already been published.[1]

---

1. Air Quality Criteria for Sulphur Oxides
U.S. Dept. of Health, Education & Welfare,
Public Health Service,
Publication A.P. 50 Washington D.C. January 1969

Hydrogen sulphide is a less common pollutant which arises mainly from specific processes. It has an intense odor with a threshold at about 0.03 ppm and high concentrations are seldom released except in accidental emissions. Hydrogen sulphide is dangerous at high concentrations since it exhibits a depressant effect on the central nervous system, paralysing the sense of smell (which is often relied upon to give warning) and causing temporary unconsciousness so that the victim cannot take evasive action. Repeated exposures do not appear to cause sensitization or tolerance to be developed.

Elemental sulphur can be formed by the vapour phase reaction of SO_2 and H_2S or the material can be wind-blown from stockpiles. Aerosol sulphur is said to be a lachrymator yet there is no evidence of adverse effects of handling or breathing the dust.

Mercaptans and most other organic sulphur compounds have intensely disagreeable odors. There is no record of health involvement because they are seldom found in sufficient concentration to cause harm and at dangerous levels the odor becomes intolerable. However, there is circumstantial evidence that continued exposure to odors, even "attractive" odors such as new bread or coffee, can eventually become objectionable and lead to depression and depression-related morbidity.

D. EFFECTS OF SO_2 AND SULPHUR DUST UPON VEGETATION AND SOILS

Damage to vegetation by air pollutants such as SO_2, HF, and oxidants has been widely reported. Of these pollutants, sulphur oxides are the most widespread in the atmosphere because they are formed during the combustion of nearly all fuels and are emitted from chemical, metallurgical and processing facilities.

The effects of sulphur oxides upon vegetation are dependent on the following factors:

1. the actual composition of pollutant since synergism and predispositions can result from combinations of gases;
2. the rate of pollution, ie. quantities released, concentrations, duration of exposure, frequency of exposure, and actual time of release;
3. the pollutant tolerance of individual plants as determined by their genetic potential, or the sensitivity and predisposition of individuals in a plant community;
4. the influence of climatic factors including ambient air temperatures, air humidities, and light quality and quantity; and
5. the influence of edaphic factors such as soil moisture and nutrition.

Acute injury following exposure to high concentrations of

SO_2 over short intervals ranges from rapid death of some foliage to complete plant mortality. Chronic injury resulting from prolonged exposure to low concentrations (eg. 0.03 ppm) ranges from a gradual foliar discoloration to growth defects and predisposition to other damaging agents.

Sensitivity to sulphur oxides varies among plant species. Among the most sensitive plants are species of mosses and lichens which have been found to be unable to live in annual mean concentrations of SO_2 exceeding 0.016 ppm[4]. Alfalfa is also a SO_2 sensitive plant, and it has been used to define the relative sensitivity of over 100 other species and varieties[5]. Acute damage occurs to alfalfa within one hour at a concentration of 1.25 ppm SO_2. Chronic injury or reduction in growth has been found with plants exposed to SO_2 concentrations as low as 0.01 ppm.

This damage to plants used for agriculture, forestry or ornamental purposes is often of greater economic than biological importance. In some instances farmers have been discouraged from growing sensitive crops in the

---

[4]Gilbert, O. L. 1968. The effect of SO_2 on lichens and bryophytes around Newcastle upon Tyne. pp. 223-235 IN Air Pollution, Proceedings of the First European Congress on the Influence of Air Pollution on Plants and Animals, Wageningen.

[5]Magill, P. L., Halden, F. R. and Ackley, C. 1956. Air Pollution Handbook. McGraw-Hill.

vicinity of air pollution sources[6]. In extreme cases of SO_2 emission, such as have occurred at Sudbury, Ontario and Trail, British Columbia, known annual losses in forest production have been estimated to exceed $100,000[7].

In field surveys in Alberta, the impact of air emissions from gas processing plants upon various forest vegetation types is being assessed. Results of these studies are not yet available but will be released through the Canadian Forestry Service, Edmonton.

Elemental sulphur is employed in agriculture to acidify soils. As it becomes oxidized by soil bacteria, sulfuric acid is formed. Oxidation of 1 to 2 tons of sulphur dust will lower the pH of an acre of most soils by about 2 pH units. Obvious effects upon soils of sulphur dust from processing plants are presently confined to areas surrounding sulphur crushing, loading and storage areas. Fine dust particles must also contribute to the ambient sulphur content of air and rainwater. However annual deposition of sulphur contained in precipitation has been found to be only 2 to 4 pounds per acre in central

---

[6] Lacasse, N. L. 1970. Conservation of our environment. IN Teachers' Conf., Proceedings (Held in Univ. Pk. Pa. April, 1970) Penn. State Univ. Pub. No. 160-70, 5pp.

[7] Linzon, S. N. 1970. Economic effects of sulphur dioxide on forest growth IN Air Pollution Control Assoc. Proceedings of 63rd Annual Mtg. (Held in St. Louis, Mo. June, 1970) 134 pp.

Alberta[8]. Since many Alberta soils are in fact sulphur deficient, the effects of sulphur emissions and dust upon soil productivity should be viewed as a problem local to stockpile facilities. A buffer zone of several acres surrounding these facilities will be necessary to prevent damage to adjacent land. An associated local problem is that of surface and groundwater contamination by compounds leached from the soil and resultant pH changes of the water. To prevent this contamination, land in the buffer zone will require special cropping and liming practices. Acid-resistant trees and shrubs could be used in this zone and soil pH's should always be maintained above 4.5

---

[8] Walker, D. R. 1971. Emission of sulfur oxides into the atmosphere and the sulfur content of Alberta soils. Paper presented at Annual Mtg. Air Pollution Control Assoc. (Held in Calgary, Alberta. Nov. 1971).

E. EFFECTS OF SULPHUR OXIDES ON MATERIALS

Sulphur oxides generally accelerate corrosion after conversion to sulphuric acid in the atmosphere or on metal surfaces. Several studies in Chicago, St. Louis, and Pittsburgh, U.S.A. have demonstrated a fairly direct relationship between metal corrosion rates and mean annual SO_2 concentrations in the range of 0.03 to 0.12 ppm[9]. The useful life of overhead line hardware and guy wires in direct windline of SO_2 fumes and in valleys traversed by railways was reduced to about two-thirds of that for these materials in areas with only average pollution (0.05 ppm SO_2). Similarly, corrosion of steel was 30 to 80 percent faster in urban environments with high SO_2 concentrations as compared to rural areas. Other materials that can be adversely affected by atmospheric SO_2 include: painted surfaces, textile fibres, dyes, and leather and paper products.

Sufficient cost studies of materials deterioration due to sulphur oxides have not been done to allow a comparison between the cost of pollution control and the replacement cost of damaged property. However, a recent out-of-court settlement for damage to property, livestock, and health by air pollution from gas processing plants in the Pincher Creek, Alberta area, amounted to $700,000.

---

9. Air Quality Criteria for Sulphur Oxides. 1969. U.S. Dept. Health, Education, and Welfare, National Air Pollution Control Administration, Publication No. AP-50, Washington, D.C.

F. AIR POLLUTION METEOROLOGY

It is only in recent years that any definitive studies related to air pollution potential have been made in Canada. (Pollution potential is not to be confused with pollution concentration; the form is simply a measure of the dispersive capacity of the atmosphere. High pollution potential must be combined with a large input of pollutants to cause high pollution concentrations.)

Wind direction and speed, turbulence and stability have the most important influence on the diffusion of pollutants in the atmosphere. Several factors contribute to air pollution potential. The height of the layer in which pollutants are diluted by vertical mixing (the 'mixing height') and the strength of the mean wind within this layer are two such factors. A third is the strength of the surface wind.

Results of meteorological studies which are important with regard to the environmental effects of the operation of sulphur extraction gas plants are as follows:

(a) In a study of the frequency and intensity of early morning inversions at Edmonton, Munn and Emslie[10] show that there is more often a ground-based inversion than not at 5 A.M. in all seasons.

---

10. Munn, R.E. and Emslie, J.H., 1964. The frequency and intensity of early morning ground inversions at Edmonton 1950-1960; CIR-4009, TEC-511, Dept. of Transport, Meteorological Branch of Canada.

December to February yield the largest number, with a minimum in summer. The most intense was 23°C in December which is equivalent to intense inversions found in the Arctic. The average depth was about 250 m which is 150 m above the normal depth of inversions due to lake breezes along shorelines in spring and early summer.[11] There were 18 intense inversions in the 10 year period studied and four or five by season. One might expect a severe inversion once per year over the autumn-winter period.

Synoptic conditions in each severe case were similar and somewhat unique to Alberta. This implies that significant success can be expected in forecasting air pollution potential conditions.

(b) A more recent climatological study of ground-based inversions by Munn et al[12] allows a comparison of conditions on a regional basis. Patterns of night-time inversion frequencies show a slight maximum extending from Montana through Edmonton to Ft. Nelson. This zone of high frequencies is a consistent feature in other seasons but most pronounced in winter.

---

11. Shenfeld, L., 1970, Meteorological Aspects of Air Pollution Control; Atmosphere, Vol. 8, No. 1, 1970, 9.

12. Munn, R.E., Tomlain J., Titus, R.L., 1970. A Preliminary Climatology of Ground-Based Inversions in Canada; Atmosphere Vol. 8, No. 2, 1970.

In Alberta and other Prairie Provinces, the climate is typically continental with inversions on most nights and lapse conditions during the day.

Inversions persist for days during air pollution episodes. No information has been published on inversion duration frequencies for Alberta. However, the most serious potential conditions occur during the cold seasons when a stagnant continental Arctic airmass lies over the region.

Inversions are intensified when warm air advection occur over Arctic air and by subsidence due in part to mountain wave effects. The Chinook that results sometimes traps shallow surface pools of cold air particularly in valleys. Associated subsidence and subsequent radiational cooling create intense inversions which enhance high air pollution potential on the East Slopes of the Rockies. Conditions are on occasions similar to those in the Columbia River Valley studied by Hewson[13]. At times, pollution may drift up and down the valley over a 24-hour period with very little net transport.

(c) There is often a lack of turbulence or dilution in surface air over Alberta but the duration of such periods is poorly known. The "ventilation" characteristics and duration of stagnation in poor "ventilation"

---

13. Hewson, E. W., 1945. The meteorological control of atmospheric pollution by heavy industry. Quart. J. R. Met. Soc. 71, 266-282.

periods must be defined to determine the air pollution potential. A study by Shaw et al,[14] may be used as a guide in determining regional stagnation areas. They examined wind speeds of 3 m/s or less in two non-overlapping persistence classes: 24-47 hours, and 48 hours or over. In the first class, generally speaking, British Columbia, the Southern Yukon, and Northern Alberta experienced by far the greatest number of occurrences of light winds. Certain regions along the Cordillera experienced over 100 occurrences in 10 summers (about 4 per month) while east of the Rockies no locality experienced that number and most have less than 25 occurrences (once per month).

In Western Canada the frequency of light winds is at a minimum in spring and increases progressively to a maximum in winter. The area experiencing 100 occurrences increases seven-fold from spring to winter. In spring almost none of Saskatchewan experienced 25 occurrences in 10 years. As winter approaches however, the 100 - isopleth advances eastward from the Cordillera to the Saskatchewan-Alberta border. An interesting minimum of occurrences are recorded consistently throughout the year in the Peace River-Swan Hills area.

---

14. Shaw, R.W., Hirt, M.S. and Tilley, M.A., 1972. Persistence of Light Surface Winds in Canada; Atmosphere, Vol. 10, No. 2, 1972.

British Columbia, Yukon and Northern Alberta also suffered most from light winds lasting 48 hours and longer. East of Alberta throughout the year there were few occurences of light winds in this class.

The study points out that the valleys of the Cordillera and Northern Alberta have frequent occurrences of light winds relative to the Prairies. These spatial and seasonal variations in persistent light winds suggest that, in the mountain valleys topography is the major factor, while in other regions synoptic weather patterns are more important.

A climatological study of ventilation is underway by the Atmospheric Environment Service which will hopefully better define the pollution potential climatology of Alberta.

(d) There is little in the scientific literature with regard to the disposition of SO_2 emissions in Alberta, average patterns of surface impingement of plumes, average area of sensitivity to offensive odor and fall-out patterns of dustfall from sulphur stockpiles. All of these matters are important for planning future plants sites and the location of nearby residential (urban and rural) facilities.

Summers and Hitchon[15] found that most of the sulphate detected in rain and hail collected in Central Alberta is of local origin. Although they had no data on sulphate content of precipitation over a wider area downwind of the sources, they suggested that summer convective storms remove most of the SO_2 before the air leaves Alberta.

Very little SO_2 is removed by snow near the source and because of greater atmospheric stability in winter it is likely carried long distances before being removed from the atmosphere.

(e) Patterns of ground level concentrations of pollutants from gas plants is often complex due to the variety of meteorological conditions experienced in Alberta. Much is known about plume rise and dispersion for "ideal" (steady wind and long uniform fetch) conditions but much remains to be determined with regard to conditions of light winds, strong inversions and strong convection. During light winds for example, hot plumes may set up local looping circulations[16], that create high

---

15. Summers, P.W. and Hitchon, B. 1971. Source and budget of sulphate in precipitation from Central Alberta, Canada. Paper presented at 1971 Annual Mtg. Air Pollution Control Assoc. (Held in Calgary, Alberta, Nov. 1971.)

16. Munn, R. E., Eggleton, A. E. J., Facy,L., Pack, D. H., Schmidt, F. H., 1972. Dispersion and forecasting of air pollution; Technical Note No. 121, World Meteorological Organization, Geneva, Switzerland, 5-16.

ground level concentrations near the source.

The effects of topography compound the problem and the advice of Scorer[17] is recommended. When undertaking a chimney-height design study in mountainous or foothill terrain, an experienced air pollution meteorologist or local meteorologists should be consulted for information on regional and mesoscale (local) weather patterns.

A proper air quality monitoring network should provide quality data on the nature and concentration of pollutants as well as complementary meteorological data. It is realized that the Province of Alberta has had regulations and air quality monitoring programs in effect for several years. No doubt these are periodically updated in view of new technology and increased public concern. Standardization of instruments, methods of data collection, quality control and analysis would aid environmental research.

As long as gas plant emissions escape the factory fence, especially near urban centres, there will be a need for air pollution potential forecasting programs to support pollution control agencies. An experimental air pollution potential model developed by the Atmospheric Environment Service is now operational and will support the Alberta Department of Environment air quality control programs.

---

17. Scorer, R.S., 1968. Air Pollution Problems at a Proposed Merseyside Chemical Fertilizer Plant. A case study. Atmos. Envir. 2, 35-48.

ENVIRONMENTAL QUALITY OBJECTIVES FOR NATURAL GAS PROCESSING PLANTS

Ambient Air Quality - Under the Clean Air Act, the Federal Government has proposed National Air Quality Objectives for five major contaminants - sulphur dioxide, particulate matter, carbon monoxide, photochemical oxidants and hydrocarbons. These objectives state maximum acceptable levels which correspond in concept to the secondary air quality standards of the United States. This level is intended to provide adequate protection against effects on vegetation, materials, animals, soil, water, visibility and personal health and well-being. These levels are the realistic objective for all parts of Canada; and if these levels are exceeded, control action by a regulatory agency is indicated.

The maximum desirable levels define the long term goals for ambient air quality and provide a basis for an anti-pollution policy for un-polluted parts of the country and for the development of control technology. The objectives for the development of more efficient sulphur recovery processes should be based on these proposed levels for sulphur dioxide. The proposed objectives as announced in October, 1971 are as follows:

Maximum Acceptable Levels

Sulphur Dioxide

- 60 micrograms per cubic meter (0.02 ppm) annual arithmetic mean.
- 300 micrograms per cubic meter (0.11 ppm) as a maximum 24 hour concentration.

- 900 micrograms per cubic meter (0.34 ppm) as a maximum one hour concentration.

Particulate Matter

- 70 micrograms per cubic meter annual geometric mean.
- 120 micrograms per cubic meter as a maximum 24 hour concentration

Carbon Monoxide

- 15 milligrams per cubic meter (13 ppm) as a maximum eight-hour concentration.
- 35 milligrams per cubic meter (30 ppm) as a maximum one-hour concentration.

Photochemical Oxidants

- 30 micrograms per cubic meter (0.015 ppm) annual arithmetic mean.
- 50 micrograms per cubic meter (0.025 ppm) as a maximum 24 hour concentration.
- 160 micrograms per cubic meter (0.08 ppm) as a maximum three hour concentration.

Hydrocarbons

- 160 micrograms per cubic meter (0.24 ppm) as a maximum three hour concentration.

Maximum Desirable Levels

Sulphur Dioxide

- 30 micrograms per cubic meter (0.01 ppm) annual arithmetic mean.
- 150 micrograms per cubic meter (0.06 ppm) as a maximum 24-hour concentration.
- 450 micrograms per cubic meter (0.17 ppm) as a maximum one-hour concentration.

Particulate Matter

- 60 micrograms per cubic meter annual geometric mean.

Carbon Monoxide

- 6 milligrams per cubic meter (5ppm) as a maximum eight hour concentration.
- 15 milligrams per cubic meter (13 ppm) as a maximum one-hour concentration.

Photochemical Oxidants

- 20 micrograms per cubic meter (0.01 ppm) annual arithmetic mean.
- 30 micrograms per cubic meter (0.015 ppm) as a maximum 24 hour concentration
- 100 micrograms per cubic meter (0.05 ppm) as a maximum one-hour concentration.

Specific emission levels can be derived from these maximum acceptable levels by calculating ground level or receptor concentrations using plume rise and dispersion equations. The acceptable emission rates would in turn be the theoretical quantity of gaseous or particulate emissions, for a particular production rate and efficiency of collection devices, that will keep pollutants below acceptable levels. Meteorological conditions at a given site must be considered in applying dispersion factors and when planning, engineering or siting new plants. On-site monitoring by standard methods of both air quality and meteorological parameters is an essential part of the application of ambient air quality objectives.

Odors from hydrogen sulfide or other sulphur compounds, such as mercaptans and carbon disulphide, are best dealt with from a public health or common law standpoint, since they may interfere with the use and enjoyment of adjacent property. However, damage to property or person must be indicated before an odor can be termed a nuisance.

Actions of nuisance can only be taken by lawful occupiers of land subjected to a nuisance if their health, comfort or convenience is imparied in relation to that which generally exists among others in their immediate community. While nuisance actions are not easily resolved, they may be avoided by gas processors if offensive compounds are incinerated completely to SO_2, and its level is controlled as described above.

Sulphur dust emissions should be contained within an industrial area and buffer zone. Soil and water pollution control techniques will be required in this area to prevent excess acidification or erosion of soil, and the resultant acidification or sedimentation of ground or surface water. Such techniques should include dust suppression.

Water Quality - Water pollution control for gas processing plant effluents should conform to objectives for petrochemical and chemical industries, and accepted surface water quality criteria should be applied. Information on this topic can be obtained from the Water Pollution Control Directorate, Environmental Protection Service, Department of the Environment, Ottawa, and it is not dealt with further in this brief.

It is obvious from the foregoing that the desire of the Federal Government is to cooperate with the Provinces to promote and help in the control of pollution from processing plants. The Federal Government believes that pollutants should be contained and removed. It is recognized that there will normally be a residual amount which can only be collected at a very high cost, and it is acceptable to disperse this material as a last resort. However, taking the wide view, the dispersion of normal industrial wastes into the environment causing damage - knowingly or unknowingly - to those downstream is an anti-social act which cannot continue unchallenged. Therefore it is the Federal Policy to promote the containment and removal of all pollutants by the best practical means and only to accept dispersion (e.g. by tall stacks) as an interim solution pending further improvement in our pollution control technology.

H. RECOMMENDED RESEARCH AND MONITORING

- Concentrations of hydrogen sulfide, carbonyl sulfide, carbon disulfide and other chemicals emitted along with SO_2 from processing plants should be measured so that their ecological impact can be more accurately assessed.

- On-site studies should be conducted to analyze interactions between specific meteorological conditions; other air pollutants, such as particulate matter; and the ecological impact of emissions from processing plants.

- An overview study should be conducted to put natural gas processing into perspective with other similar sources of air pollution, such as tar-sand processing, and with other desulphurization processes such as those used for coal.

- Cost studies of property damage due to specific air pollutants would be useful in evaluating the cost-benefit relationships for control equipment.

- Studies to assess the health effects of sulphur emissions in the rural environment, including effects of odors upon man and wildlife would be useful, since most health data presently come from urban settings.

- Consideration should be given to establishing a meteorological tower on a suitable site on the tarsands, as the frequency of light winds suggest that it is an area of high pollution potential.

QUESTIONING BY THE AUTHORITY

DR. S. B. SMITH

There is one very important matter of principle dealt with, a direct quote from your Minister. "We are reluctant to rely on nature's assimilative capacity because we simply do not know enough about the science of ecology to predict the results."
In Calgary, two qualified witnesses stated, one without equivocation at all, that nature's assimilative capacity for sulphur was not even being approached because detectable levels of SO_2 could not be found rising in the atmosphere. Would you care to comment on that from a technical point of view.
The other one inferred very strongly that nature's assimilative capacity was not being approached. These are, to my mind, directly in contradiction with the quote made from your Minister which I presume is on the advice of some technical person.

DR. H. ETTER

No, I can't comment on their private information. I can merely reiterate that we do not know, in our opinion, the assimilatory capacities of nature.

DR. S. B. SMITH

So you are saying, from your familiarity with what you know of the biological capacity of the environment to assimilate, that we don't know.

DR. H. ETTER

I don't know of those specific terms.

DR. S. B. SMITH

Do you think that the natural assimilative capacity is being approached or do you not know? Let me ask you that as an individual.

DR. H. ETTER

I would support the position of the Department in this. More study needs to be done.

DR. S. B. SMITH

That isn't really what I asked you. I asked you as a technical person, do you think the assimilative capacity is nearly being reached or not.

DR. H. ETTER

I think I answered your question.

DR. S. B. SMITH

Do you think epiphytic lichen holds promise?

DR. H. ETTER

It is a fact lichens are very sensitive to changes in their gaseous composition and their atmosphere. The presence of lichen communities, their rates of growth and their quick color change with small changes in the atmospheric environment have the potential as a biological indicator.

DR. S. B. SMITH

Do you think they could be used to establish a base line against which species such as poplars or pines or others could be measured?

DR. H. ETTER

This has been done in laboratory experiments as they are referred to for alfalfa.

DR. S. B. SMITH

Could it be done in the wild?

DR. H. ETTER

I am not aware of any studies.

DR. S. B. SMITH

Are they predictable enough that they might provide a good base line?

DR. H. ETTER

I wouldn't want to conjecture on that.

MR. W. A. FLOOK

Other than rates, is there any characteristic of the type of corrosion produced by sulphur dioxide that would allow you to use it as an indicator? Could you identify corrosion due to sulphur dioxide as opposed to corrosion due to normal oxygen?

DR. H. ETTER

In the studies that I referred to, I measured the concentration of SO_2 and there was only corrosion due to SO_2 present, therefore they could correlate the two. I point out, however, that we are unable to indicate the effects of a specific pollutant upon the life of materials in a complex of pollutants. I'm not aware of any studies that can pin down and say that the corrosion is due only to SO_2.

MR. W. A. FLOOK

You referred to 5:00 a.m. inversions in Edmonton being a fairly normal thing, more often present than not. How long do they last?

DR. H. ETTER

You'd have to refer to that study. There was a reference at that point.

MR. W. A. FLOOK

Regarding your reference to looping plumes setting up very high ground level concentrations of the contents, assuming a stack producing a normal 10,000 parts per million of sulphur dioxide, would you care to comment on the type of concentration that might occur at ground level.

DR. H. ETTER

No, I wouldn't.

MR. W. A. FLOOK

You wouldn't even hazard an opinion as to range, 1 part per million, 100 parts per million?

DR. H. ETTER

I think we could measure it in a field if such occurred.

MR. W. A. FLOOK

But you wouldn't have any knowledge of it or opinions, at the moment.

DR. H. ETTER

I imagine some of the technical people do, particularly in the Atmospheric Environments Service and in the Air Pollution Control Directorate.

DR. W. R. TROST

Dr. Etter, there's been a considerable amount of discussion and the presentation of a particular point of view from industry as to where control can best be done: at the ground level or in the stack. It seems that your position favors one of these as against the other. Do you want to elaborate a little bit on that?

DR. H. ETTER

We favor the position of measuring the pollutant at the receptor, a person at a particular point distant from the source, or a plant; or a bird flying over the top of the stack. You must define the receptor, therefore as an interval element of applying ambient air quality objectives.

DR. W. R. TROST

Does that correspond with what you call your best practical means approach as well?

DR. H. ETTER

Yes, we feel it does. We feel the two are integrated.

DR. W. R. TROST

What form would your conclusions take when applied to this specific case of these sulphur extraction gas plants? Where should the point of control be best located?

DR. H. ETTER

Well, a monitoring program would have to be devised for each site that would monitor the ambient air quality and associated meteorological parameters, and from this one would be able to define something which you might refer to as an emission. The two are inter-related.

Mr. J. G. Gainer summarized

the Canadian Petroleum Associations

brief presented in Calgary

QUESTIONING BY THE AUTHORITY

DR. W. R. TROST

Mr. Gainer, we have questioned the brief very extensively but there is still one point that I'd like to refer to. You say that while one may well question, in an environmental effects investigation, the relevancy of such matters as (1) foreign ownerships of both plants operating and construction companies or (2) the few personnel directly employed etc. etc. I checked through Dr. Klemm's report and I didn't see where they appeared in his report. Would you be so good as to check with Dr. Klemm and see if in fact those two statements did appear?

MR. J. GAINER

We have not disbanded our task force and would be pleased to submit an epilogue to the total hearings if it would contribute to your findings in any way.

DR. W. R. TROST

We'd be pleased to receive such an epilogue, Mr. Gainer. If I can now call on Mr. Geddes, a private submission. Mr. Geddes, please.

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS IN ALBERTA

Brief submitted by: W. Geddes

My name is Bill Geddes and I have no written submission. They're just some comments as a result of a Pincher Creek law suit for which I happened to be counsel. Over a period of some six years I have a few personal views which might be of interest to some people here and I'll give those and be happy to answer questions.

I have heard a bit about the emission levels, and over the period of years I had to do a fair bit of reading in that area. It became apparent to me at an early time that there was a great deal of dedicated effort directed to scientific investigations based on normal scientific investigation procedures. There are all kinds of reports, conclusions and recommendations which have been presented to this hearing and have been recorded previously. The results of these seemed to be that there was an effort to set a standard, be it .03 or .05 or .1 or whatever, this standard based on the normal and proper process of scientific investigation. These standards have been presented in materials, standards set in Los Angeles, Montreal, Finland, Helsinki, Moscow; and there's nothing that I can criticize with respect to the investigation procedures there, except that I question whether in Alberta anybody has ever talked to the people, or looked at it from an entirely different investigation procedure.

Once you set an objective standard, you are making an initial assumption that all people are the same, and the fallacy in the whole system of studying that standard is that all people are not the same. I faced this problem for some six years, because initially in the Pincher Creek situation which involved about eighty-two people. One person died during the law suit and two or three were born into it. It involved an experience by an isolated community commencing in 1957 and continuing as we sit here today.

Fifteen years ago there was no environmental conservation board; there wasn't any public interest really at that point; there wasn't experience within the sulphur extraction industry or in any other industries in this country or in many other countries. People at that time didn't have all of that massive information and experience that I think people here today have. Back in those years, however, people complained about problems. They complained about problems at night, as opposed to the daytime, and they complained that their children were affected more than they were. There were more complaints from women than men, and one of the early government enquiries, 1962 or 1963 used the word "psychological complaints". In that report there were over 485 complaints during the year. The conclusion by a number of people was that there was no problem.

We all know that any type of complaint of this nature; subjective complaints and sometimes emotional complaints, are with all of us. Everyone in this room here either feels warm, hot, very hot, or something, but no two people react similarly to the obvious overload on the air conditioning in this room right now. If any person investigated all of you and took a report he wouldn't get two answers the same. The same thing applies with odor, smell, noise and speed, taste; any of our senses. Saying .03 is a safe standard is an obviously wrong thing. It's going to be tolerable for some people, it's not for other people. Obviously there has to be some standard. I suppose it's the distinction between those two approaches to the problem of ground level concentrations. When I first started looking at criteria, .3 parts per million ground level concentration for sulphur dioxide was the standard. This was considered to be a standard that nobody could smell or notice.

I became rather interested that women and children complained more than men. Some research was done, through the U.S. Department of Interior or Health or someone that showed some studies in other countries where they tested younger children and found that their tolerance was less, and that adults' tolerances were more. A lot of these people's complaints began to fit into place then, which previously had been

described as psychological. Because they complained that young children had nose bleeds but no adult reported a nose bleed; and they complained that the children coughed at night and woke up at night, but they didn't; I believe that different classifications of people have different tolerances.

They were always talking about averages, average ground level fall-out. The problem was really instantaneous fall-out, so the monitoring procedures didn't exactly fit the people's complaints. There were a series of Stevenson Screens, or "birdcages", on the fenceposts which measure average levels. There were titrilogs or trailers that measured instantaneous concentrations, because of the terrain these couldn't get to some areas. With regard to the experience and the equipment available at the time, people involved did as much as they could to do the checking. It's not any criticism of them that maybe today their conclusions were, in my opinion, wrong, because some of this happened fifteen years ago.

As a lawyer I had to take into consideration the emotional involvement that anybody in a law suit has. People do have a personal involvement with a law suit; both the farmers down there and the industries involved. There was a bias on both sides. Having that in mind and looking at the comments about the psychological problems of my clients I became concerned with seeing whether there was an unusual group of people there as opposed to in some other area.

I interviewed, by letter or personally, around a hundred people, some who lived outside the area affected, some as far away as other provinces; and found that there was a great deal of legitimate complaint by people who had no involvement. That helped me in assessing the alleged psychological problems of the clients.

Another thing was corrosion. There were allegations of corrosion of farm machinery and fencewire. I compared a 1958 John Deer tractor near the plant and a 1958 John Deer tractor in Stavely. I got some people who were auctioneers and who sold them, and they gave me some valuations. We did some comparisons with fencewire, not a methodical

type of investigation because there weren't that many people involved but enough in my judgement, to illustrate that there was a noticeable difference with machinery and wire.

Then came the question of hogs and cattle. You can get provincial averages for hog production, I think it's 9.3 pigs per litter in Canada and some people there were saying they were getting 6 and 7 pigs per litter. What's changed? There's no water change, feed, management; it's the same chap, the same barns, everything is the same; only one different thing. The problem was the young pigs, which brings us back to the young children, the young calves and so on. This is all in the face of this standard,I think it was .3.

Another factor is the number of people who complained were not all the people. The people that complained were more affected than the other people. You have to keep that in balance too. If your work out percentages on the number of complaints and the number of hogs or cattle or children the percentages are very, very small. They're fractions of a percent. And it occures to me today that probably no one has ever done an in-depth survey of the people. There's been lots of surveys of machines, recording devices and outlet temperatures; but I wonder if anybody's ever surveyed the people and tried to relate their experiences to some of these other very intangible things.

I must say that the real problem with this situation was the way that the government boards and officials handled the situation. There were inquiries which developed this information about people having emotional problems which I don't think should ever have been done. For a period of a year and a half I tried to look at government records of letters from my people which normally is something that you can get from the other side and it took me a couple of trips to the Attorney General's Department. I had the probably unique experience of looking at the records of two defendants and the Government and correlating them with what the people said. There were complaints by one oil company against the other. There was another occasion where there was a report by one company that the government officials in the area

had reported eighteen separate complaints that day, but there wasn't anybody that would ever verify that. Somebody wrote down a conversation from somebody that there were eighteen complaints. All I could get out of admissions from anybody was about five. That's a matter of record.

I suppose the only benefit of history of any sort is to look back and see if there can't be improvements in the future. I'd read one extract through from a report back in 1960, some twelve years ago; I'm going to read an extract from it. There was a very careful analysis of some livestock or some hogs done by the Department of Agriculture here. They reported on their findings and the number of tests they made. They post-mortemed twenty-three pigs, sixty guinea pigs, eight rabbits and spent a great deal of time doing this. The conclusion: "We cannot say at what concentrations or for what periods of time such changes would occur. In practical terms the following statement would appear justified: this particular group of pigs on the premises of one of the clients had suffered ill-effects similar or indistinguishable from lung damage produced in our experiment, experimental swine, exposed to sulphur dioxide evidenced by impaired growth rate and changes in the respiratory tract." There's your statement after a great deal of investigation in 1960. After that people had no problems. They were just kind of mental problems. I have often wondered how anyone could make such a statement in the face of such an investigation which I accept was carried out.

I have interviewed certain employees of both plants who acknowledged to me that there were problems. In the order of ten I interviewed, eight, said they didn't have a problem. I also interviewed someone in engineering who had been involved, had lived in the area, and had run some of the testing. He said he didn't smell a thing and he lived there three months. I accept his view as accurate. I mention this because I don't want anybody to misinterpret my remarks as meaning that anybody had deliberately mis-stated a position. I just think that the conclusions, maybe, were wrong.

QUESTIONING BY THE AUTHORITY

DR. W. R. TROST

You've been talking about events that have taken place some time ago. Have you any knowledge, perhaps through continued connection with your clients, as to how things may be now as compared with how they were then?

MR. W. GEDDES

It's my own opinion that the situation there has improved. I accept that both plants in the area have made diligent efforts to improve the situation.

DR. S. B. SMITH

Are there mechanisms available under other acts which allow people this kind of approach to Government, as compared to this particular situation? Or is it possible to develop them?

MR. W. GEDDES

I'm not aware of any particular other area of redress. You complain to the person who you have the complaint about, and if you don't get satisfaction you have three remaining recourses. You have the news media, government, and you have the law courts to go to. Most people, they're mad. If they don't get redress through the news media, or through government agencies, then they sometimes come to a lawyer, sometimes they don't - they just go away and complain.

DR. S. B. SMITH

There are a couple of acts dealing with resources in which people who feel themselves aggrieved have direct recourse to Ministers. It's supplied in the legislation and the Minister then can provide a vehicle under which negotiations might be carried out.

MR. W. GEDDES

The Workmen's Compensation Board is an example of that. The difficulty there is that a set of standards are set and then they're never changed; so that, to a certain degree, the compensation that you get does not meet the compensation that you would get through the law courts. Which means that if I'm injured on compensation I recover "x" damages, if I'm going home from work. If, however, I'm injured going home from a basketball game by the same person I recover "y" damages. It creates a completely artificial situation.

MR. W. A. FLOOK

Mr. Geddes, you make a very strong and very important point about individual susceptibility to environmental conditions and implied that at the level that was for twelve years the standard was applicable apparently to just about hit half of the population, presumably down the middle. If you were attempting to set standards, there are obviously three ways you could set them. One, it could be set on practical considerations irrespective of its effect. Two, you could attempt to avoid any effect on anybody. Or three, you could attempt to protect a majority. What do you suppose would be an appropriate way to set these standards?

MR. W. GEDDES

I didn't suggest that only half the population was affected. That was a matter of degree and in my opinion all of the people were affected, some more than others. The minute that you set any standard you must acknowledge that you are going to affect some people in some way. Therefore, if you don't want to have any people affected in any way whatsoever, you don't have plants, cigarettes, automobiles, detergents or automatic dishwashers, central heating, you don't have all of the things that we have. There isn't one person, I suggest, in this room who if they were asked to give up their T.V., their car and all of the other things that we're accustomed to would vote for it. So we acknowledge that we are going to have things that affect people. We have to accept some inconvenience, and then with the wisdom of Solomon someone has to set that level.

In the Pincher Creek situation two things happened: the level was wrong. It's improper in these proceedings to comment on somebody else's words but Mr. Gainer said it very accurately, there are unusual meteorological and topographical factors there. There were these things there and they created extra problems that nobody could perceive. Once aware of this,maybe the standards in, for example Pincher Creek, have to be different from the ones in Whitecourt. How do you compare standards right across the province anymore than people right across a community?

I do accept there have to be standards. Set standards but leave a form of redress to those exceptions to the average person. There are many who feel they are affected and can prove that they are. And there could be some easier procedural methods than going to court. I think it's the most adequate way to deal with it. Don't set a standard which says if industry stays under that standard then there is no liability because you're then saying anybody who is affected has no possible way of recovering.

MR. W. A. FLOOK

It brings up a very important point. Compliance with the law then would not automatically infer protection from redress. If the plant could prove that it was complying with the legal regulations it could still be sued.

MR. W. GEDDES

There are many examples where people comply with the law but still inflict injury on someone.
It's been pointed out to me that I didn't answer your questions earlier.
One of the elements of the settlement at Pincher Creek was the form of document permitting a certain amount of continued pollution. In effect as long as there is any form of pollution, there is going to be somebody affected in some way. The problem is drawing the level, and you do not want to inflict upon the people, individual people; or alternately industry, a continuing day to day law suit over the next hundred years. Things have to reach some form of stability, and one of the forms of settlement in its own record at the Land Titles Office in Calgary, was that in finalizing things there was an easement permitting an amount of pollution or effluent onto the lands of the plaintiffs up to only those standards

set by any governmental authority. If those standards are exceeded or if there are upsets or excesses, then the people have the right to go back and start over again to obtain relief. If the standards change lower, then the permissibles go lower, if they go higher, they go higher. The plants adjacent to these people's lands can emit effluent to those levels. Some of the people are unhappy with our solution. The plants were unhappy with this solution. They didn't like the idea of being subject to further lawsuits, and the people didn't like having their certain right to complain removed. Some people were willing to do it, and others weren't. Unfortunately, in order to finalize it, there had to be an unanimous approach. The benefit of finalizing that particular struggle that had gone on with some people for twelve or thirteen years, far outweighed any inaccuracy there might be in agreeing to an easement permitting the effluent.

"THE ROLE OF SULFUR

AS A NUTRIENT

IN AGRICULTURAL PRODUCTION

IN ALBERTA"

A Brief

by

The Alberta Institute of Agrologists

Presented by: R. E. McAllister

Presented at a Public Hearing

Called by the Environment Conservation Authority

Concerning the Environmental Effects of the

Operation of Sulfur Extraction Gas Plants

Edmonton, Alberta

October 19, 1972

INTRODUCTION

Sulfur is an element essential as a nutrient in plant and animal growth and as such is of vital importance in the production of food by agriculture.

Sizable regions in Alberta, having soil deficient in the forms of sulfur usable by plants, are incapable of producing economic crops without sulfur fertilization.

Forty years ago the Alberta Government was deeply concerned over the depressed economic position of farmers in the wooded area lying west and southwest of Edmonton on the light colored soils. Without a substantial increase in crop yields land abandonment appeared inevitable. Soil scientists from the University of Alberta assumed the task of building a high level of fertility into this impoverished soil. This they accomplished by a now widely adopted soil management program based on legumes, sulfur and nitrogen, thereby making sulfur deficient Gray Wooded soils equal in productivity to much of the most fertile land in this province.

In this productivity improvement program the vital scientific contributions stemmed mainly from university graduates in Agriculture, the large majority being members of their professional society, the Alberta Institute of Agrologists. Membership in the A.I.A. requires involvement in matters of the public interest, as evidenced by the publication last year of the Institute's handbook, "Agriculture and the Environment".

As the use of sulfur in food production is in the public interest, the A.I.A. believes it has responsibility to ensure that the role of sulfur in agriculture is understood by society in general. This is especially important at this time when concern for the environment and some adverse effects of sulfur bearing emissions from sulfur extraction gas plants are receiving much publicity. Accordingly this brief presents data originating in Alberta, or applicable to Alberta, establishing the economic and nutritive importance of adequate supplies of available soil sulfur to Alberta agriculture. The A.I.A. hopes this presentation will lead to an understanding of the public benefits to be derived from recommended use of sulfur fertilizers when that element is deficient in agricultural soils.

PRODUCTIVITY IMPROVEMENTS BY SULFUR FERTILIZATION

In the early 1930's available soil sulfur was found to be a major limiting factor in crop production on Gray Wooded soils at Breton in west central Alberta. This determination was made on the now famous Breton Plots established by the Department of Soil Science of the University of Alberta in an effort to overcome the regional economic depression stemming from persistent very low yields of grain and forage crops. Sulfur, however, was not the only important limiting factor as the soil's available nitrogen also was much below the requirement for good crops (University of Alberta 1971 a).

Furthermore, and related to its development under forest in contrast to prairie grass, the soil was very low in organic matter a constituent which is essential for good tilth and is the major reservoir of many essential plant nutrients.

The research program on the Breton Plots determined it was not possible to grow high yielding legume hay crops without supplying sulfur. Moreover it was not possible to produce good grain yields without preceding the cereals with vigorous healthy legume stands. These determinations demanded the replacement of the grain-fallow cropping practice by a crop rotation using legumes, with sulfur and nitrogen fertilization for the legumes and cereals respectively.

The application of sulfur increased legume hay yields (Alfalfa or Clover) to very economic levels, frequently doubling or quadrupling the yield of unfertilized stands (Table 1). The basic crop rotation consisted of legume hay, legume hay, wheat, oats and barley with each crop being produced every year in a five-year rotation of fields. No land was fallowed. The wheat crop, in the position immediately following sulfur fertilized legume, produced an average annual yield of 35 bu. per acre in a long-term (1940-1963) evaluation program (Table 2) which is about 15 bu. greater than the provincial average of 19.7 bu. per acre for the same period (Alberta Department of Agriculture 1969). This specific yield achievement resulted from the application of approximately 10 lbs. of sulfur (in SO_4 form), per year, per acre. The key to the production of economic cereal crops, on soil deficient in

available sulfur, is the use of sulfur on legumes.

The rapid adoption by farmers of the new soil management system was facilitated by readily available supplies of ammonium sulfate and ammonium phosphate-sulfate fertilizers, of the following analyses:

	N %	P_2O_5 %	S %
Ammonium Sulfate	21	-	24
Amm. Phosphate-Sulfate	16	20	14

These two fertilizers, included in the original (1930) experiments, produced during a 34-year program, an annual average yield in the order of two tons of hay and nearly doubled grain yields secured by crop rotation without fertilization (Table 3).

Research and demonstrational programs have not been confined to the Breton district as indicated by the results from seven locations in the Peace River area where combinations of sulfur and nitrogen fertilization produced 1,200 to 3,400 lbs. of additional barley or oats per acre, representing yield increases of 100% to 350% above the unfertilized crop (Table 4). In similar field experiments, again on sulfur deficient soils in the Peace River region, barley was increased from 13 cwt./acre (25 bu.) to 39 cwt./acre (82 bu.), while rapeseed yields were increased from 2 or 3 cwt. to 16 and 17 cwt. by the combined effect of sulfur and nitrogen fertilization (Table 5).

The yield responses reviewed above relate only to those Gray Wooded soils that are sulfur deficient. In very recent years yield limitations due to sulfur shortage are appearing at scattered locations in other soil zones in Alberta, as a result of the single or combined effect of one or more of the following factors:

(a) low available sulfur status when brought under cultivation,

(b) sulfur removal by crops (Fig. 1)*,

(c) reduction of soil organic matter content (Brown, Wyatt and Newton 1945).

As the Gray Wooded soils of the province contain only about half as much extractable (available) sulfur as the Black or Dark Brown soils (Fig. 2)*, in their original or virgin status, it is not surprising that sulfur deficiencies have only recently been identified in the latter two types. In the more arid regions of Alberta (the Brown soil zone) sulfur is even less likely to be a factor limiting crop yields because of high levels of sulfur containing salts (alkali) in many of those soils.

Currently virtually all sulfur used on Alberta crops is applied as Ammonium Sulfate ($(NH_4)_2SO_4$) either as the compound itself or in physical blends with other fertilizers such as ammonium phosphate, ammonium nitrate, or urea.

Where sulfur is recommended to correct a deficiency the application rate in terms of elemental sulfur (S) normally falls between 5 and 20

* "Figures 1 and 2 are not reproduced in these proceedings due to their color content but are available at the Information Center, Environment Conservation Authority, 9912 - 107 Street, Edmonton, Alberta."

pounds per acre for the crop year, depending upon the crop grown and the relative degree of deficiency.

Sulfur fertilization is low cost. When sulfur is a constituent of commercial fertilizers (i.e., ammonium sulfate), it is essentially ignored in the price structure. If recommended rates of sulfur applications were made as elemental sulfur the cost would be less than one dollar per acre at current prices.

IMPROVED CROP QUALITY

There is conclusive proof that recommended use of sulfur supplying fertilizers improves the quality, grade and nutritive value of crops being grown on sulfur deficient soils (University of Alberta 1971 b). At Breton the grade of wheat as well as the color, texture and loaf volume of bread made from it was improved by sulfur supplying fertilizers. Amino acid determinations made in those grains found that sulfur fertilization improved the proportions of the most important of those vital requirements. Rabbits fed forages and rats fed grains that had been grown on sulfur fertilized plots made greater gains per unit of feed intake than comparable animals fed materials grown at the same time on unfertilized adjacent plots (University of Alberta 1959).

On a large number of samples legumes grown on sulfur fertilized soil contained an average of 20 to 25 percent more protein than the unfertilized legumes grown on the same sulfur deficient soils. At Breton wheat grown after sulfur fertilized legumes contained an average of 12.5 percent protein compared to 10.0 percent in wheat grown at the same time on adjacent fallowed plots. Such results are to be expected since sulfur is a constituent of three amino acids which constitute a significant portion of most proteins (University of Alberta 1971 b).

EXTENT OF SULFUR DEFICIENT SOILS

Deficiencies in available soil sulfur sufficient to seriously depress crop yields were found in Alberta in the early 1930's on the Gray Wooded soils at Breton, some fifty miles southwest of Edmonton. Since then experimental work and soil surveys indicate that one-third to two-thirds of the main body of the Gray Wooded soils may be sulfur deficient (University of Alberta 1971 c). The acreage involved is very large as such soils constitute over one-half of the currently cultivated plus potentially arable area of this province. Presently 15% of Alberta's cultivated land lies in this soil zone, a level that could rise to 40% of the province's arable land in the next few decades.

During the last five years, visible symptoms of sulfur deficiency in crops have appeared in both Black and Dark Brown soil zones (Fig. 2) at widely separated locations. This expansion of areas having inadequate levels of available soil sulfur is not surprising in view of the many years of net sulfur removal by crops (Fig. 1). Sulfur deficiency is usually associated with soils having good drainage, coarse texture (sandy) and a relatively low content of organic matter. As organic matter is a major reservoir of available sulfur, it's reduction in soil may lead to a deficiency of sulfur for crops. It is noteworthy that the reduction in organic matter content of cultivated land is accelerated very significantly by the use of summerfallow. Thus sulfur deficiency may become an increasing problem in some Black and Dark Brown soils of Alberta in the next few decades.

SOIL TESTING

There are two methods for determination of sulfur deficiency in agricultural soils. The traditional and most reliable procedure is to apply sulfur supplying fertilizer to crops and observe their yield response. That method is slow. More recently reasonably satisfactory soil test procedures have been developed using as a comparative base the quantity of available sulfate-sulfur (SO_4-S).

Soils with an available SO_4-S content of 0 to 3 ppm are likely to produce increased crop yields if fertilized with sulfur supplying fertilizers. Soils with 3 to 5 ppm may or may not respond to sulfur fertilization while soils with more than 5 ppm of SO_4-S are seldom responsive to sulfur fertilization (Carson, J.A., Credin, J.M., and Nemunis - Siugzdinis, P. 1972). Since the 1930's it has been known that Gray Wooded soils are frequently deficient in sulfur. It is only during the last few crop seasons that signs of sulfur deficiency have been appearing in some of the Black and Dark Brown soils in this province (Fig. 2). An evaluation of the sulfur status of Alberta soils was done in 1970-71 by the Agricultural Soil and Feed Testing Laboratory, by analyses of 3443 samples from specific areas (Table 6). This survey indicates 13% of the soils tested are probably sulfur deficient, while 30% are at or below the 5 ppm threshold level.

FATE OF SULFUR BEARING EMISSIONS

The fate of sulfur bearing emissions from Alberta sulfur extraction gas plants is only partly known. Some, or all of it, comes to earth in precipitation or by adsorption by plants and soils. Sulfur (S) deposits in a range of about 5 to 20 pounds per acre per year approximately meet the needs of growing crops (Fig. 1).

On sulfur deficient soils such depositions can be beneficial to crops and plants. if the rate of deposition is not harmful to their tissues. However, these depositions have an acidifying effect which is roughly cumulative and proportional to the amount of sulfur so deposited. At present the range and intensity of sulfur deposition on soils in the vicinity of sulfur extraction plants, as well as the effects of those deposits on soil chemistry, are not known in adequate detail in respect to agricultural and environmental concerns. These matters require elucidation because of the expectation that sulfur extraction will continue for many years in Alberta.

SUMMARY

1. Relatively large regions of soils in Alberta are sulfur deficient while others are showing indications of becoming sulfur deficient, from the standpoint of producing satisfactory crop yields.

2. Soils may be deficient in available sulfur due to a low sulfur status as virgin soil or by the removal of sulfur through cropping, or by a combination of both factors.

3. Sulfur deficiencies inhibiting the production of satisfactory crops can be overcome by the application of appropriate sulfur supplying fertilizers at recommended rates in recommended cropping systems. Normally, the economic gains to farmers are very substantial.

4. The conversion of much sulfur deficient land from low productivity to high productivity status has been achieved by the application of the findings of agricultural researchers. Despite the progress made to date, the full understanding of soil, plant, sulfur inter-relationships, including determination of the fate of sulfur bearing emissions from sulfur extraction gas plants, requires further research as soon as possible.

RECOMMENDATIONS

The Alberta Institute of Agrologists recommends:

- that the essential role of sulfur in agriculture be recognized and protected in respect to any legislation or regulations concerning sulfur in relation to the environment;

- that in depth agricultural research on the fate of sulfur bearing emissions from sulfur extraction gas plants be undertaken as soon as possible.

Submitted on behalf of the Alberta Institute of Agrologists, by these members:

C. F. Bentley

C.F. Bentley, Ph.D., P.Ag.

R.E. McAllister, M.Sc., P.Ag.

October 19, 1972

Edmonton, Alberta

LITERATURE CITED

ALBERTA DEPARTMENT OF AGRICULTURE. 1969. Historical Series of Agricultural Statistics for Alberta, Publication No. 850.

BROWN, A.L., WYATT, F.A., NEWTON, J.D. 1945. Effects of Cultivation and Cropping on the Chemical Composition of Some Western Canadian Prairie Soils. Sci. Agric. 25: 718-737.

CARSON, J.A., CREPIN, J.M., NEMUNIS-SIUGZDINIS P. 1972. A Sulfate Sulfur Method Used to Delineate the Sulfur Status of Soils. Can. J. Soil Sci. 52: 278-281.

DEPARTMENT OF SOIL SCIENCE, UNIVERSITY OF ALBERTA. 1968. The Breton Plots History. Mimeograph. (See Plot 15, 1940-1963).

UNIVERSITY OF ALBERTA. 1959. Gray Wooded Soils and Their Management, Bulletin No. 21, Fifth Edition, Revised: 57-60.

UNIVERSITY OF ALBERTA. 1971 a. Gray Wooded Soils and Their Management. Bulletin B-71-1, Seventh Edition, Revised: 16-26.

UNIVERSITY OF ALBERTA. 1971 b. Gray Wooded Soils and Their Management, Bulletin B-71-1, Seventh Edition, Revised: 56-66.

UNIVERSITY OF ALBERTA. 1971 c. Gray Wooded Soils and Their Management, Bulletin B-71-1, Seventh Edition, Revised: 8.

TABLE 1

AVERAGE YIELDS & INCREASES OF LEGUME HAY
FROM THE APPLICATION OF SULFUR AT BRETON, ALTA.
1940 - 1963

	Response to Sulfur, lbs./acre	
	Total Yield	Increase Over Control
1st. Year Hay	4,470	3,090
2nd. Year Hay	4,380	3,190

SOURCE: Department of Soil Science, University of Alberta.1968.
The Breton Plots History. Mimeograph. (Plot 15)

TABLE 2

AVERAGE YIELDS & INCREASES
FROM THE APPLICATION OF SULFUR ON WHEAT
FOLLOWING FALLOW AND FOLLOWING LEGUMES
1940 - 1963, BRETON, ALTA.

Treatment	Wheat Following Fallow (1)	Wheat Following Legume (2)
	Bu./Acre	Bu./Acre
Sulfur (3)	30.3	35.2
No Sulfur	25.9	22.0
Increase	4.4	13.2

(1) As it requires two years (one in fallow and one in crop) to produce these yields, the average annual production per acre is one-half the yield shown.

(2) Wheat follows legume in this five-year rotation, viz., legume-legume-legume-wheat-oats-barley. No land is idle in fallow. The average annual production per acre is the yield shown for each crop, as each crop is grown every year.

(3) 7 lbs. of Sulfur, per acre, per year.

SOURCE: Department of Soil Science, University of Alberta. 1968. The Breton Plots History. Mimeograph.

TABLE 3

THE EFFECT OF AMMONIUM SULFATE AND AMMONIUM PHOSPHATE-SULFATE ON YIELDS OF HAY AND GRAIN ON BRETON PLOTS

1930 - 1963

(Yields Per Acre)

	5-Year Crop Rotation					Wheat After Fallow (1)
Nutrient Applied	Hay 1 Lbs.	Hay 2 Lbs.	Wheat Bu.	Oats Bu.	Barley Bu.	Bu.
Amm. Sulfate (2)	3,790	3,940	32.0	47.8	24.5	21.9
None	960	620	15.0	28.4	13.1	17.3
Amm. Phosphate-Sulfate (3)	4,370	4,240	32.0	51.3	28.2	26.0
None	1,320	650	17.8	31.8	17.0	19.7

(1) As it requires two years (one in fallow and one in crop) to produce these yields, the average annual production per acre is one-half the yield shown.

(2) Provides 9 lbs. of sulfur per acre, per year.

(3) Provides 5 lbs. of sulfur per acre, per year.

SOURCE: Department of Soil Science, University of Alberta
The Breton Plots History. 1968. Mimeograph.

TABLE 4

EFFECT OF NITROGEN AND SULFUR ON YIELD OF BARLEY OR OATS
GROWN ON SULFUR-DEFICIENT GRAY WOODED SOILS
IN THE PEACE RIVER REGION

	Yields of Grain (cwt. per acre) at Different Sites						
Fertilizer Applied*	1	2	3	4	5	6	7
None	10.9	5.1	11.6	-	12.5	15.6	11.7
Sulfur	10.8	6.1	12.0	11.8	11.5	16.5	-
Nitrogen	15.4	8.5	12.6	10.8	26.7	36.2	41.9
Nitrogen plus Sulfur	28.7	23.1	24.1	32.9	31.7	40.5	46.2

* Nitrogen fertilizer added at rates of 60 or 80 lb. N/acre;
Sulfur fertilizer added at rates of 10 or 20 lb. S/acre.

SOURCE: Nyborg, M., Bentley, C.F., 1971.
Sulfur Deficiency in Rapeseed and Cereal Grains.
University of Alberta.
Agriculture Bulletin No. 15, p.p. 13 - 15.

TABLE 5

EFFECT OF NITROGEN AND SULFUR ON YIELDS
OF GALT BARLEY AND ECHO RAPESEED
GROWN ON TWO SULFUR DEFICIENT GRAY WOODED SOILS
IN THE PEACE RIVER REGION

Fertilizer Applied *	Yield (cwt./acre) Coldstream Soil Series		Braeburn Soil Series	
	Rapeseed	Barley	Rapeseed	Barley
None	2.2	13.1	3.5	15.6
Sulfur	3.3	14.4	5.2	20.4
Nitrogen	0.3	13.0	0.8	12.2
Nitrogen Plus Sulfur	17.2	39.5	16.0	35.6

* Nitrogen fertilizer added at rates of 100 lb. N/acre; sulfur fertilizer added at rate of 20 lb. S/acre.

SOURCE: Nyborg, M., Bentley, C.F., 1971.
Sulfur Deficiency in Rapeseed and Cereal Grains.
University of Alberta.
Agriculture Bulletin No. 15, p.p. 13 - 15.

TABLE 6

PERCENTAGE DISTRIBUTION OF SOILS TESTED FOR SO_4-S IN ALBERTA

	Areas (1)				
SO_4-S (ppm)	1	2	3	4	Provincial Total
0 - 3	11	8	18	10	13
3 - 5	19	18	22	14	17
5 - 8	26	23	26	18	21
+ 8	44	51	44	58	49
Total Number of Samples	539	986	964	954	3443
Mean	9.6	12.4	10.8	13.4	11.8

(1) Area 1 - Township 1-32, west of the 5th meridian.

Area 2 - Township 33-70, west of the 5th meridian.

Area 3 - Township 53-73, range 1-27, west of the 4th meridian.

Area 4 - Peace River Area.

SOURCE: Carson, J.A., Crepin, J.M., Nemunis-Siugzdinis, P. 1972 A Sulfate Sulfur Method Used to Delineate the Sulfur Status of Soils. Can. J. Soil Sci. 52: 281.

QUESTIONING BY THE AUTHORITY

DR. W.R. TROST

We both recognize that elemental sulphur, hydrogen sulphide and sulphur dioxide are the kinds of emanations that may come from the sulphur extraction plants. Before they are utilized by the plants, presumably they must be changed into a sulphate. Is that right?

MR. R.E. MCALLISTER

Sulphate is the major form in which they are taken up; but in some of the texts you will see reference to sulphur dioxide being absorbed by the tissues, or into the plants.

DR. F. BENTLEY

It is possible for the sulphur requirements of crops to be met by the intake of sulphur dioxide. This has been established with tracer studies and so forth, so it is questionable.

DR. W.R. TROST

Would that be at levels below the appearance of damage in the leaf?

DR. F. BENTLEY

Yes.

DR. W.R. TROST

At certain levels it can in fact be taken up advantageously.

DR. F. BENTLEY

That is correct.

DR. W.R. TROST

In the general transformation of the sulphur compounds, as it takes the sulphate form it might normally, or under some circumstances, first appear as sulphuric acid?

DR. F. BENTLEY

The sulphuric acid would react with the soil giving you virtually instantaneous sulphate salts; calcium, magnesium, sodium, potassium, other sulphate salts; so that there is this very rapid reaction between the sulphuric acid and the soil components.

DR. W.R. TROST

That results from the fact that our soils tend to be a bit on the alkaline side.

DR. F. BENTLEY

We do have quite a range in different parts of the Province, as to whether soils are alkaline or acid or near neutral. Generally in the southern part of the Province, there was a higher original content of calcium carbonate in the geologic materials on which the soils have formed. In addition because of high evaporation and in some cases, somewhat lower annual precipitation, those soils tend to be on the neutral or alkaline side and sometimes up to the vicinity of pH 8 or so because of presence of calcium carbonate still in the upper soil layers. In central Alberta and in wooded regions, the general tendency is for soil to be on the acidic side. A majority of soils are not strongly acidic. We do, in parts of Alberta, have soils that are extremely acidic. We also have relatively small areas by comparison; but amounting to hundreds of thousands of acres even in the grassland and prairie areas of central and southern Alberta; where, due to the pedogenic processes involved in their development, there is a strongly acid surface layer, underlain by a strong alkaline layer, anywhere from four to eight inches below the surface. You change from the strongly acid, to the strongly alkaline condition.

DR. W.R. TROST

Now, evidence has been given earlier that under circumstances the accumulation of sulphur may increase the acidity at the surface, and then the applications of lime restore the situation. Does calcium sulphate also have the property of making sulphur available to the plants?

DR. F. BENTLEY

Calcium sulphate has itself a very low solubility, sufficiently soluble to act as

a sulphur fertilizer if there are a few weeks for it to be dissolved prior to the needs of the plant being manifested.

DR. W.R. TROST

At Calgary, one of the gentlemen suggested that they might get rid of the great amounts of sulphur as a fertilizer. Do you want to comment on that?

DR. F. BENTLEY

The estimate was that current emission if uniformly distributed over the Province would give three pounds per acre; but if instead of being uniformly distributed over the Province, it is coming down on one tenth of the area and is thirty pounds per acre. If it was coming down over an area of about four square miles in the vicinity of the plant, then it would be the equivalent of about five tons of sulphuric acid an acre a year. I'm not aware of any information that indicates for any given plant the actual fate of the emissions. What proportion comes down within, let us say, ten square miles, within a hundred square miles or within one mile.

DR. W.R. TROST

Where does the commercial fertilizer that contains sulphate come from? How is it made?

DR. F. BENTLEY

Ammonium sulphate is produced, for instance, at Fort Saskatchewan as a consequence of the processing of nickel. At other sulphur or fertilizer plants sulphuric acid is used to treat the rock phosphate in order to produce phosphoric acid. You have the sulphur then from the sulphuric acid wither going into the tailing or into the ammonium sulphate depending just on the plant process.

DR. W.R. TROST

So it's generally the sulphur derived from sulphur minerals that is used to get the metal from?

DR. F. BENTLEY

The origins of the Cominco Fertilizer Industry at Trail was that of some thirty or forty years ago. Because of effects of emissions of SO_2 from their processing of sulphide ores for lead, zinc and so forth, they were required to discontinue emissions on that level. The sulphur was converted to sulphuric acid as a means of removing it from the stack, and they got into the fertilizer industry as a means of using the sulphuric acid they had on hand as a result.

MR. R.E. MCALLISTER

With respect to calcium sulphate, the trials at Breton included gypsum for quite a while, and other field trials were done with gypsum. It's a little slower reaction; but it will yield, on the basis of sulphur, legume increases like what we saw on the charts. It has the disadvantage of generally being very fine, powdery; and it is very difficult to apply; but otherwise the sulphur in it is good fertilizer.

MR. CARSON

Through some of these Hearings, we talked of sulphur dioxide almost as a fallout. Our emissions from the stack in sulphur form are in sulphur dioxide which is in a gaseous form and does not fall out. I would understand it to precipitate out under certain conditions. Maybe during a rainfall, under certain environmental conditions, we could have a sulphurous acid type of thing forming and you could have a precipitate, instead of normally a gas which dissipates. Could anyone clarify or expand on this?

UNKNOWN (from the audience)

Plant tissues, soils, and water can absorb sulphur in sulphur dioxide as gaseous material. Also snow, and rainwater falling as precipitation can dissolve them; but surface waters, soils and living vegetation can absorb some sulphur, and this is part of why in our submission we say that there is a need to know what is the fate of the sulphur dioxide that is being emitted. Is it being taken up by waters? Is it being taken up by plants? Is it affecting the soil pH, and so forth?

DR. W.R. TROST

Dr. Summers is a meteorologist and he is our next speaker and he may possibly just handle your question in the course of the discussion. Otherwise we'll handle it subsequently.

SOME METEOROLOGICAL ASPECTS OF EMISSION OF SO_2 FROM SULPHUR EXTRACTION GAS PLANTS AND THE POSSIBILITY OF INADVERTENT WEATHER MODIFICATION EFFECTS

by

Peter W. Summers*
Meteorologist

Submission to the Public Hearing of the Environment Conservation Authority on the Environmental Effects of the Operation of Sulphur Extraction Gas Plants

Edmonton
19 October 1972

* Although employed by the Research Council of Alberta, the views presented here are those of the author as a professional meteorologist and do not necessarily reflect the views of the Research Council of Alberta or the policy of the Government of Alberta

INTRODUCTION

a. After attending the Public Hearings held in Calgary on 16 October 1972 it was apparent that some of the meteorological aspects of the SO_2 emissions from sulphur extraction required clarification and elaboration. These were:

(i) the limitations of the diffusion equations for predicting downwind SO_2 concentrations, especially the ground level values on which the ambient air quality standards are based

(ii) the unique meteorological conditions in Alberta, such as Chinooks, which may cause special problems

(iii) the possible inadvertent weather modification effects of SO_2 pollution, which were briefly alluded to but not discussed in detail.

b. This submission is an attempt to present a preliminary discussion of these aspects for the information of the Authority and especially to point out where gaps in our knowledge exist and where further research is required.

c. The submission will be split into two parts. Part I will discuss the atmospheric dilution problem and Part II will discuss the possibility of inadvertent weather modification effects.

PART I

SOME METEOROLOGICAL ASPECTS OF SO_2 POLLUTION

1. LIMITATIONS OF THE DIFFUSION EQUATIONS

a. The currently used prediction equations apply only when the atmospheric lapse rate is neutral or unstable and the results are valid to distances of the order of 5 - 10 miles downwind of the source.

b. Ambient air quality standards are based on the maximum ground level concentrations (ground level is chosen because most people, animals, plants and property are located there) and these prediction equations are used to design the stack height so that the ground level ambient air quality standards are met.

c. Several prediction models are available and there is as yet no general agreement on which ones should be used. However, they all give essentially the same results and if the effluent is emerging from the stack orifice with zero buoyancy then the maximum ground level concentration C* is given by

$$C^* = \frac{2Q}{e\pi u h^2} \qquad 1)$$

where Q is emission rate of the pollutant, u is the mean horizontal wind speed in the layer between the ground and the height (h) of the top of the stack. Thus for a given source strength and wind speed the maximum ground level concentration is inversely proportional to the square of the height of the stack.

d. The effluent is usually warmer than the ambient air and thus rises some distance above the orifice before the effluent loses its buoyancy. Calculating the height of rise is a complex problem especially in conditions with strong horizontal winds, but it results in an effective stack height h* which is greater than h, and from which the plume can be thought to originate.

e. It can readily be seen that one way of meeting the ambient air quality

standards is to keep the orifice high and the effluent hot. However, there is an economic limitation here, because whilst the maximum ground level concentration decreases as the inverse of the square of the effective stack height, the stack cost increases roughly as the cube of its height.

f. The behaviour of the atmosphere under neutral and unstable lapse conditions and the design of stacks under these conditions is fairly well understood. But in Alberta these atmospheric conditions occur only a fraction of the time. Frequency distributions of the occurrence of various atmospheric stability conditions are not available, but it is estimated that neutral and unstable conditions exist during a substantial part of the daylight hours in the summer months but only very infrequently in the winter. On the other hand stable conditions, inhibiting vertical mixing and diffusion, exist most of the time at night,summer and winter,and also right through the 24 hours on many days during the winter because of the snow cover. In addition, specific problems such as chinook conditions occur close to the foothills and can put a severe restriction on vertical mixing in winter. The looping plume, which causes short bursts of high concentrations close to the stack, can occur in any geographical location under very unstable conditions and although very important to the nearby residents, the problem is a local one and will only be commented on briefly here.

2. THE LOOPING PLUME PROBLEM

a. The main problem is obtaining accurate statistics on frequency of occurrence and measurements of the actual concentrations within the plume as it strikes ground. Assuming that the area hit by one descent to ground is only 200 ft across, then the chances of a sampling station within an area of 5 mile radius around a source being at that location is 1 in 62,500. Depending on the number of days on which looping plumes occur and the frequency with which bursts of effluent strike the ground the chances of detection are increased. However, a very dense network of sampling

stations would be required in order to get any meaningful measurements.

b. It is therefore necessary to make some reasonable assumptions about the plume expansion by the time it reaches ground. Time-lapse photography of plumes with infra-red film could be a very useful tool here. Once the plume dimensions are determined a mass flux balance of air and pollutant through the stack orifice and within the plume should enable the range of possible pollution concentrations to be estimated.

3. TRAPPING OF SO_2 IN STABLE CONDITIONS OR UNDER INVERSIONS

a. This type of condition frequently occurs in Alberta, and has not received nearly enough study to date. Some of the aspects to be considered and a simple model approach to this problem are given below.

b. The simple box model and mixing depth concept can be applied in this case to indicate the variables involved and make some "ball-park" estimates of the SO_2 concentrations possible in this situation. The basic components of such a model are shown schematically in Fig. 1. This mixing depth concept was developed for urban areas by Summers (1965) and has since been widely used. Recently it was applied to New York City and excellent agreement was found between predicted and observed SO_2 concentrations (Leahey, 1972).

c. The input into the box is a flux F_s of SO_2 given by

$$F_s = AVC \qquad 2)$$

where A is the area of the stack orifice, V is the gas velocity out of the orifice and C is the concentration of SO_2 in the effluent. The output from the box is the flux of SO_2 through a vertical cross-sectional area at right angles to the mean wind (u) flow at a distance downwind (D). If the plume has been uniformly mixed through the whole depth (H), and has spread through a horizontal width W at a distance D downwind, then the flux F_d of SO_2 through this area is given by

$$F_d = HWuC^* \qquad 3)$$

where C^* is the concentration of SO_2. Assuming that absorption of SO_2 by the soil and foliage is small in distance D, and further that no oxidation of the SO_2 has taken place, then mass conservation requires that:

$$F_s = F_d \qquad 4)$$

or

$$AVC = HWuC^* \qquad 5)$$

or the dilution factor C^*/C is given by

$$\frac{C^*}{C} = \frac{AV}{HWu} \qquad 6)$$

d. Equation 6 contains all the essential components to allow an estimate of the dilution factor to be made; or if C is known an estimate of the actual concentration downwind. The numerator in the right hand side of the equation is a stack parameter and the denominator is dependent on meteorological conditions and is essentially a "ventilation" factor.

e. The meteorological parameters are not completely independent. H may be related to u, and W will be related to both H and u. Unless constraints are imposed by topography W must be greater than H. These relationships are such that over level terrain there is a physically possible lower limit to the ventilation factor. This would then place an upper limit on the ground value of C^*.

f. Clearly there is a lower limit to H which cannot be less than h for the model to apply. In this case we have a lofting plume with effluent being dispersed in the unstable air above and not reaching the ground. Thus increasing the stack height increases the lower limit of the dilution factor.

g. In the case of pollution sources located in a valley, meteorological factors determine H and u, but W is independently limited by topography such that ventilation can be very low leading to high values of C^*.

h. Each situation would require that the gas plant inputs and the meteorological

constraints be assessed in order to arrive at the range of possible downwind values of C*.

4. CONCLUSIONS

a. Under those meteorological conditions in which the standard diffusion prediction equations apply, the ambient ground level pollution standards can be met by simply designing the stack an appropriate height to produce the required dilution of the known rate of SO_2 output.

b. The above conditions probably pertain less than 50% of the time in Alberta and a simple box model can be applied to cover the conditions much of the remaining time. In this model the maximum ground level concentrations downwind are either related to the inverse of the stack height or are independent of stack height.

c. In the lowest several thousand feet of the Alberta atmosphere averaged over wide areas and long time periods the concentrations are completely independent of stack height.

d. In all cases (a, b and c) the concentrations are directly related to the emission rate, but the proportionality constants are different.

e. Stack design can thus be used to ensure that ambient air quality standards are met, and hence public health protected, close to the plant, without control on total emissions. But, the general level of SO_2 in the Alberta atmosphere, which produces more subtle effects such as sulphate deposition on the soil and possible inadvertent weather modification effects, is dependent only on total emissions. This later point is discussed in more detail in Part II.

5. RECOMMENDATIONS

a. A study needs to made to determine what percentage of the time the standard diffusion prediction equations are valid.

b. Models, such as the simple one proposed here, need to be developed to provide predictions of concentrations of SO_2 in the rather unique conditions often present in Alberta, due to Chinooks and long winter snow cover.

PART II

THE POSSIBILITY OF INADVERTENT WEATHER MODIFICATION EFFECTS

6. INTRODUCTION

a. There is increasing concern that atmospheric pollution is already producing, or may in the future be producing, inadvertent changes in weather and/or climate on the local, regional or world-wide scale. These changes could be either detrimental or beneficial.

b. Some of the more obvious pollution sources that may produce these changes are:

(i) heat and water vapour emitted into the urban atmosphere

(ii) gases and particulates emitted into the atmosphere by combustion and industrial processes

(iii) water vapour injected into the upper atmosphere by high flying aircraft

c. In a few cases, where long term meteorological records in a sufficiently dense network are available, strong evidence of man-produced changes are well documented.

d. It is thus possible that the large amounts of SO_2 emitted into the Alberta atmosphere by the sulphur extraction gas plants may now be having an effect on the weather, or if they are allowed to increase may have an effect in the future. This possibility will now be further considered.

7. NATURAL PRECIPITATION PROCESSES

a. There are two basic precipitation-forming mechanisms, the condensation - coalescence process and the freezing process. A simplified description of these follows.

b. In the first case cloud droplets form around cloud condensation nuclei (CCN) which are found naturally in the atmosphere in large numbers. The most efficient of these are hygroscopic nuclei such as NaCl (from sea-spray)

and various other chloride and sulphate particles. Provided some of these particles are present, they will form cloud droplets that are larger than – and thus have a fall velocity relative to – the remaining droplet population. These larger droplets collide with the small droplets and grow by coalescing with them thus starting the chain reaction leading to raindrop growth and fallout. Showers in temperate maritime regions and tropical regions are frequently formed by this mechanism without going through an ice phase.

c. The freezing precipitation growth mechanism requires that the cloud droplets be supercooled to the point where natural freezing nuclei cause them to freeze. An ice crystal once formed in a supercooled cloud environment grows rapidly and starts the chain reaction leading to hail or snow, which may melt and reach the ground as rain.

d. Often both processes operate in the same cloud system, and the probability of a given supercooled droplet freezing depends not only on the presence of a freezing nucleus but also on the droplet diameter. Thus the presence of hygroscopic condensation nuclei which produce larger droplets also has an indirect effect on the freezing process.

e. Clearly then the addition of large numbers of artificial hygroscopic CCN into the atmosphere has the potential for affecting the precipitation growth mechanism.

8. EVIDENCE FOR EFFECTS ELSEWHERE

a. Huff and Changnon (1972) show that in some seasons a considerable enhancement in precipitation occurs downwind of some major cities in the USA. Two possible explanations are suggested: (i) an increase in the dynamic energy of storms due to the heat released by the urban area or (ii) an increase in the CCN or freezing nuclei released in the pollution caused by the city. It is difficult to separate out the two effects, but both are probably important although with different emphasis at different times and for each city.

b. In the case of St. Louis, Mo. a large project (METROMEX) has been set up to study in detail the physical cause and effect relationships between the heat, moisture and pollution input of the city and downwind inadvertent weather modification effects. Aircraft measurements (Auer 1972) have already indicated large increases in CCN concentrations over and downwind of St. Louis.

c. In Washington State, a study of Hobbs et al. (1970) provides strong evidence of precipitation increases of about 30%, with very high statistical significance, downwind of several major industrial pollution sources. These sources are large pulp and paper mills and aircraft measurements have detected large numbers of CCN in the plumes downwind of the mills.

d. The CCN were identified as hygroscopic sulphate and sulphite particles (in addition there was some free SO_2). The most common particle in the effluent was Na_2SO_4 and it was estimated that the total emission for all mills in the State was 20 tons per day, with some of the larger mills producing CCN at the rate of 10^{19} per sec.

e. The study by Hobbs et al. extended into southern B.C. and similar effects were noted near Victoria and to a lesser extent in the lower Fraser Valley. The statistically most significant increase in rainfall in the whole area studied was noted downwind of Trail, B.C. In this case there was also a marked decrease in precipitation further downwind; however, the situation here is complicated by the large number of pollutants emitted in addition to SO_2, including the possibility of some freezing nuclei.

9. EVIDENCE FOR EFFECTS IN ALBERTA

a. Whilst not nearly as well documented as elsewhere, there is some evidence for effects in Alberta that may be related to SO_2 emissions. The level of hail damage as recorded by the Hail Insurance Board has shown a gradual downword trend in many parts of the province during the last 10 - 15 years. At the same time soft hail has been reported with increasing frequency (Summers 1968).

b. The most dramatic drop in hail damage has occurred in the region north and northeast of Calgary commencing in about 1961 and coinciding with the region of maximum SO_2 output. The group of sources in the Crossfield – Didsbury area currently account for nearly half of the total provincial emissions from gas plants i.e. approximately 500 tons of SO_2 per day.

c. A detailed study of the hail insurance data and rainfall records is now underway for the whole agricultural area of the province to see if the relationship between the start-up of each plant and any subsequent changes in precipitation pattern nearby and downwind can be sharpened up.

10. THE ROLE OF SO_2 IN ALBERTA PRECIPITATION

a. As a result of the suspected relationship above a study of sulphate in precipitation in central Alberta was commenced in 1967. The main findings are summarized below.

b. The summertime convective storms appear to be a very efficient mechanism for removing SO_2 from the atmosphere in the form of sulphate (Summers, 1970). Comparisons of the sulphate concentrations found in rain and hail suggest that the SO_2 is removed by rainout (incorporation into the precipitation mechanism within the cloud) rather than by washout (absorption of SO_2 by falling rain).

c. The chemical reactions which convert the SO_2 to sulphate, either in the free atmosphere or within the cloud, were not investigated; but they must be fairly rapid because much of the sulphate fallout occurs close to the source (Summers and Hitchon, 1971).

d. Sulphate concentrations in snow were found to be much lower than in either rain or hail, because the rainout mechanism cannot operate and ice crystals are inefficient scavengers of SO_2.

11. RELATION OF SULPHATE TO EMISSIONS

a. There is one major difference between the stack emissions from pulp mills

and gas plants. In pulp mills most of the sulphur in the effluent is already in the form of sulphate particles. In the case of the gas plants it is mainly SO_2 with little of no sulphate particles. However, only a very small percentage (about 2%) of the Alberta SO_2 emissions, currently running at about 1200 long tons per day, have to be converted to sulphate before entering cloud systems to produce amounts equivalent to the 20 long tons per day emitted in Washington State.

b. The amount of sulphate in precipitation is related to the concentration of SO_2 in the air feeding the storm systems. This concentration will depend on distance from the source and meteorological stability conditions and will be highly variable from day to day.

c. A sulphur budget by Summers and Hitchon (1972) showed that averaged over the summer months a substantial fraction (32 to 46%) of the SO_2 emitted from the Rimbey gas plant came down as sulphate in precipitation within a radius of 25 miles of the plant. Over a wider area of central Alberta, the data are consistent with the hypothesis that in the summer most of the SO_2 is removed from the atmosphere before it leaves Alberta. It would thus appear that only a small fraction of the SO_2 is actually removed from the atmosphere through direct absorption by foliage and the soil.

d. The amount of sulphur in precipitation is thus very close to being directly proportional to the total emission from the stacks, and if these emissions continue to increase the total amount of sulphur deposited in precipitation in the province will increase by a proportional amount. The areal distribution of this sulphur deposition will be related to the location of specific sources of SO_2.

12. CONCLUSIONS

a. Studies in Alberta show that the SO_2 emissions from gas plants enters directly into the summertime precipitation mechanism, either in the form of gas or as sulphate or both.

b. The effects noted in the State of Washington strongly suggest that the amounts of SO_2 in the Alberta atmosphere are sufficient to potentially affect the precipitation mechanism in a way that may change the amount or character (rain or hail) reaching the ground. However, because of differences in other atmospheric parameters in Alberta these changes may not necessarily be in the same direction or of the same magnitude as in Washington.

c. There is observational evidence suggesting that some effects have already occurred in Alberta. These effects and a causal link with the start-up of several of the major SO_2 sources is currently under investigation. It will not be easy to confirm these effects because of the high natural variability of summer precipitation in Alberta.

d. The magnitude of any inadvertent weather modification effects, if they are shown to exist, will in all likelihood be directly proportional to the total emissions from any one or any group of SO_2 sources.

13. RECOMMENDATIONS

a. In view of the changes in sulphur content and acidity of the soil resulting from sulphur deposition by precipitation, and the strong possibility of inadvertent weather modification effects due to SO_2 or sulphates entering into the precipitation mechanism, it is recommended that a more detailed study of the whole problem be made. This study should include the following items.

b. A fixed network of precipitation sampling stations should be operated on a year-round basis throughout the southern half of the province - from the Peace River area south. A few control stations should also be established in the unpolluted northern part of the province. The samples collected should be analyzed for sulphate and chloride concentrations and other relevant constituents.

c. Aircraft flights should be made in the plumes from gas plants and in the lowest

10 - 15,000 ft of the atmosphere through wide areas of central Alberta. Measurements of SO_2 , SO_3 ,sulphate particle and CCN concentrations should be made. Air samples should be collected and filtered to identify the specific sulphate compositions.

d. The atmospheric observations above in conjunction with laboratory work should be directed towards understanding the reactions by which SO_2 is converted to sulphate in the atmosphere.

e. All relevant meteorological data - precipitation type, amount and frequency; storm tracks etc. - should be studied in the region of and downwind of the major SO_2 sources.

f. An attempt should be made to put all of the above together to determine whether there is a physical cause and effect relationship between SO_2 emissions and significant inadvertent weather modification effects.

g. Finally,if effects are confirmed, then it will be necessary to determine whether they are beneficial or detrimental; and if the latter, then the dependence on emission rates should be determined in order to provide a guide for controlling such emissions.

REFERENCES

Auer, A.H. Jr., 1972: An Estimate of the Production of Cloud and Aitken Nuclei by the St. Louis Metropolitan Area (Project METROMEX). Proc. Third Conf. on Weather Modification, Amer. Meteor. Soc., Rapid City, S. Dak., 26 - 29 June 1972, 79-82.

Hobbs, P.V., L.F. Radke and S.E. Shumway, 1970: Cloud Condensation Nuclei from Industrial Sources and Their Apparent Influence on Precipitation in Washington State. J. Atmos. Sci., 27, 81-89.

Huff, F.A., and S.A. Changnon, Jr., 1972: Inadvertent Precipitation Modification by Major Urban Areas. Proc. Third Conf. on Weather Modification, Amer. Meteor. Soc., Rapid City, S. Dak., 26 - 29 June 1972, 73-78.

Leahey, D.M., 1972: An Advective Model for Predicting Air Pollution within an Urban Heat Island With Applications to New York City. J. of APCA, 22, 548-550.

Summers, P.W., 1965: An Urban Heat Island Model: It's Role in Air Pollution Problems, with Application to Montreal. First Canadian Conf. on Micrometeorology, Toronto, April 1965.

Summers, P.W., 1968: Soft Hail in Alberta Hailstorms. Proc. Int. Conf. on Cloud Physics, Toronto, 26 - 30 Aug 1968, 455-459.

Summers, P.W., 1970: Scavenging of SO_2 by Convective Storms. Precipitation Scavenging (1970), AEC Symposium Series No. 22, 305-318.

*Summers, P.W. and B. Hitchon, 1971: Source and Budget of Sulphate in Precipitation from Central Alberta, Canada. Pacific NW Int. Section, APCA Annual Meeting Calgary 21 - 23 Nov 1971. [In press J. of APCA].

* The last paper is attached as an appendix.

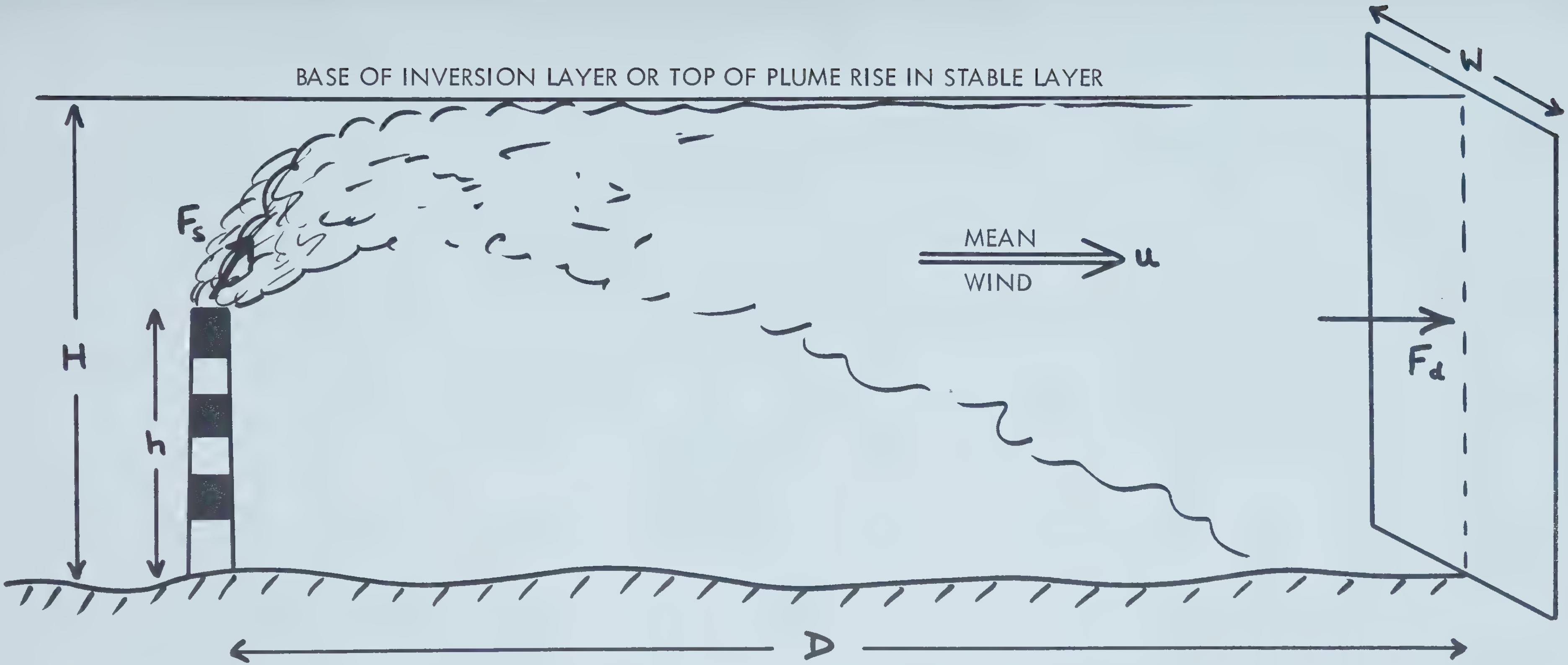


Fig. 1 Schematic representation of a simple box model indicating the parameters required for estimating downwind concentrations under stable or inversion conditions.

71-AP-16

SOURCE AND BUDGET OF SULPHATE IN PRECIPITATION FROM CENTRAL ALBERTA, CANADA

Peter W. Summers and Brian Hitchon

Research Council of Alberta
Edmonton, Alberta, Canada

For Presentation at the 1971 Annual Meeting

Pacific Northwest International Section, Air Pollution Control Association

Calgary, Alberta November 21 - 23, 1971

SOURCE AND BUDGET OF SULPHATE IN PRECIPITATION FROM CENTRAL ALBERTA, CANADA

Peter W. Summers and Brian Hitchon

Research Council of Alberta
Edmonton, Alberta, Canada

INTRODUCTION

This study of sulphate in Alberta precipitation commenced in 1966 as a result of two seemingly unrelated observations. The first was the fact that soil scientists had noted a decrease in the sulphur deficiency of some Alberta soils. The second observation was the marked reduction of hail activity in central Alberta since 1961 and at the same time an increase in the number of reports of soft hail.

It was known that the oil and gas industry in Alberta went through a period of rapid expansion in the early 1960's resulting in a sharp increase in the discharge of waste gases (mainly SO_2) into the atmosphere, primarily from gas plants processing sour (H_2S-rich) natural gas. Removal of this SO_2 from the atmosphere by cloud systems, could thus have contributed additional sulphate to precipitation which in turn would cause increased sulphate deposition on the soil. Also, evidence was accumulating from some parts of the world that anthropogenic atmospheric pollution was affecting the weather and climate on a local scale (up to distances of approximately 100 miles). It thus appeared possible that SO_2 and/or sulphate aerosols incorporated into the updrafts feeding convective storms could affect the precipitation mechanism and thus have an impact on both the eventual hydrometeors produced in the cloud system and the sulphate content of the soils.

In order to investigate these ideas a pilot project was set up in 1966 to collect and analyze precipitation samples from about a dozen locations in Alberta. As a result of this pilot project collection procedures and appropriate analytical techniques were developed, and except for minor improvements these have remained essentially unchanged since 1967.

PRECIPITATION COLLECTION

The Alberta Hail Studies Project* operates a field program every summer.[1] Project headquarters are located on the Canadian Forces Base at Penhold, about 8 miles south of Red Deer, central Alberta. Since 1967 trucks have been equipped with various sampling devices to collect rain and hail for later analysis. It was therefore decided to utilize these trucks and collect separate additional samples whenever possible for later sulphate and chloride analysis.

The sampling trucks were in radio contact with project headquarters, and weather radar was used to direct them into the predicted path of the storm. When the truck was in position, and precipitation about to begin, an 18-inch-square collector on the roof was opened and washed out with distilled water. The rain was manually sampled inside the trucks by filling pre-cleaned 200 ml plastic bottles. Whenever the rainfall rate was high enough an attempt was made to obtain sequential samples throughout the storm. The sample bottles were placed immediately in a portable cooler containing dry ice and then stored in a deep-freeze until they were melted prior to analysis. Unknown to the analyst occasional control samples of distilled water were included within the sample sequences as a check of the system.

Hail was collected in two ways. A few samples came through the collector on the roof of the truck and were separated from the rain by a wire mesh. Most samples were picked off the ground soon after fall and kept frozen. Before melting for analysis the outer layer was washed off with distilled water.

During the winter freshly fallen snow was collected at least several hundred feet from highways and as soon after the storm as possible.

SULPHATE AND CHLORIDE DETERMINATIONS

A slightly modified version of the conductometric titration method described by Egnér, Brodin and Johansson[2] was used for the determination of both sulphate and chloride.

For chloride, the samples were titrated against silver acetate since this silver salt did not give the flat portion to the curve near the knickpoint which was observed when silver nitrate was used with high chloride contents. In order to lower the sensitivity limits, all samples and standards were spiked with a standard solution containing 15 mg/l chloride as potassium chloride. This allowed a sufficient number of points to be plotted on the curve of conductance - against - titrant volume before the knickpoint was reached to have confidence in the slope of the line produced. In every case sample size was 70 ml. A series of tests were run on ten samples at 2 mg/l level of concentration, and this gave a relative standard deviation of $\pm 15.1\%$.

---

*A co-operative investigation into the nature of Alberta hailstorms carried out jointly by the Research Council of Alberta, the National Research Council, the Atmospheric Environment Service, and the Stormy Weather Group of McGill University.

Sulphate was determined by titration against barium trichloroacetate, and standards were made up with sulphate in the form of sulphuric acid and both sodium and potassium sulphates. Standard curves were identical in all cases. It was not found necessary to add sodium nitrate to increase the conductivity, as described by Egnér, Brodin and Johansson[2]. Sample size was 70 ml and the samples and standards were spiked with a standard solution of 15 mg/l sulphate as potassium sulphate, for the same reason as for the chloride determination. The relative standard deviation was $\pm 7.0\%$ based on seven determinations on a standard sample at the 3 mg/l concentration level.

For rain and hail samples collected in 1969 and 1970 the conductometric method described in the two previous paragraphs was modified slightly by both increasing the strength of the spike and the content of ethanol added to assist precipitation. These modifications, together with the use of a more sensitive recorder gave relative standard deviations of $\pm 1.6\%$ for sulphate at the 6 mg/l level and $\pm 0.9\%$ for the chloride at the 5 mg/l level.

SULPHATE AND CHLORIDE IN PRECIPITATION

Sulphate in Rain

A total of 152 rain samples, collected from convective storms during the summers of 1967 to 1970 inclusive, were large enough for the determination of sulphate content. The frequency distribution of the content of sulphate is shown in Fig. 1a), with the modal value being between 3.0 and 3.5 mg/l. Contents range from <0.1 to 12.0 mg/l, with a mean value of 2.7 mg/l and a standard deviation of 1.7 mg/l. All of the high values (>6.0 mg/l) and most of the low values (<1.0 mg/l) represent single determinations in a time sequence of samples. Each was collected over a short sampling time of a few minutes and is indicative of the large fluctuations that can occur within a single storm. In these cases, computing the average sulphate content over the whole storm, gave a range of 0.6 to 5.0 mg/l, which then agrees well with the range of averaged values of 0.2 to 3.6 mg/l found by Walker[3] in a more limited area of central Alberta.

Chloride in Rain

For 106 samples sufficient remained after sulphate analysis for the chloride content to be determined. The frequency distribution is shown in Fig. 2a). As expected for a continental interior region these values are low since the main source of chloride in precipitation is the oceans[4]. The mean value is 0.5 mg/l with a standard deviation of 0.4 mg/l. Over 93 per cent of the rain samples analyzed had chloride contents less than 1.0 mg/l.

Excess Sulphate in Rain

The ratio of sulphate to chloride by weight in sea water is 0.14. Thus the amount of sulphate in precipitation that may be attributed to evaporation of sea spray is 0.14 of the chloride content. Therefore the mean value of sulphate of oceanic origin in Alberta rain is $0.14 \times 0.5 \approx 0.1$ mg/l. The excess sulphate in Alberta rain is therefore only very slightly less than the total sulphate.

Even over the oceans in areas remote from any pollution sources there appears to be a general background of excess sulphate of approximately 0.5 mg/l in precipitation.[4] Thus the mean sulphate content in central Alberta rain that is in excess of the sum of that from the natural background and that originating from sea water is approximately 2.1 mg/l. This mean amount is probably due to local pollution sources.

Sulphate in Snow

In order to check the hypothesis that most of the sulphate in Alberta rain is of local origin, snow samples were collected in January 1969 on two traverses between Edmonton and Vancouver and at several locations in central and southern Alberta. All samples were collected within a day or two of a heavy snowfall. Both sulphate and chloride were determined on all snow samples and the histograms of frequency distribution for those samples from central Alberta are shown in Figs. 1d) and 2d), respectively. For 15 samples the mean value is 0.6 mg/l and the standard deviation is 0.4 mg/l. The regional variations of excess sulphate found in these samples are shown in Fig. 3 together with tentative isolines to emphasize the general features. Values in southern British Columbia are generally quite low except for a maxima near Penticton. Values between the Selkirk Mountains and the Rocky Mountains are below the detection limit of 0.1 mg/l. On the east side of the Rocky Mountains values increase sharply with a large area around Edmonton containing values of excess sulphate of more than 1.0 mg/l. A less prominent maximum occurs east of Calgary. The regional variations shown in Fig. 3 strongly suggest that the excess sulphate found in the snow from Alberta is of local origin.

Sulphate in Hail from Central Alberta

A small number of hail samples were collected by the mobile sampling units in the same general area as the rain samples and were suitable for analysis. The frequency distribution is shown in Fig. 1b). The mean value is 2.9 mg/l and the standard deviation is 0.7 mg/l. Thus despite the small sample size the mean value is close to that for the associated rain, although the extremely high and low contents of sulphate in the rain samples do not appear to occur in the hail. All the hailstones analyze were large (>1 inch diameter) and thus the bulk of their mass consisted of cloud water or rain water accreted within the storm cloud, since little or no further growth occurs after the stones fall below the cloud base. The chloride content of hail from central Alberta shown in Fig. 2b) is similar to that of rain and snow.

Sulphate in the Hail of the Edmonton Storm, 4 August 1969

A total of 300 hail samples were collected in the city and nearby countryside from this severe hailstorm, and 88 were analyzed for their sulphate content. The frequency distribution is shown in Fig. 1c). The mean value is 0.5 mg/l with a standard deviation of 0.4 mg/l. No samples had a sulphate content more than 2.5 mg/l

and 63 per cent were less than 0.5 mg/l. This distribution is very different from those for rain and hail collected further south and suggests that local sources did not contribute to the sulphate found in the Edmonton hailstorm. Since this storm occurred on the Monday of a holiday weekend urban pollution would be low. Also, the low level airflow feeding into this storm was from the north east and coming from a region with no known major SO_2 sources. The chloride content of hail from Edmonton storm shown in Fig. 2c) is similar to that of hail from central Alberta.

REMOVAL OF SO_2 FROM THE ATMOSPHERE

Rain is the predominant mechanism by which SO_2 is removed from the atmosphere.[4,5] There are two ways in which this occurs; by rainout or by washout. Rainount is the incorporation of SO_2 or sulphate aerosols into the cloud physical processes inside the cloud and subsequent fallout in the rain. Washout is the scavenging of sulphate aerosols or absorption of SO_2 gas by the falling rain below cloud base. This later mechanism does not appear to be important in Alberta.[6]

According to Junge[4], the rainout efficiency (ε) is proportional to the liquid water content (L) of the clouds. Data obtained in Germany by Junge[4] and by Beilke and Georgii[5] for low values of L give rainout efficiencies of 1 to 20 per cent. Case studies of three convective storms in Alberta[6], for which information was obtained to enable a complete sulphur budget to be determined, confirmed this relationship for higher values of L. These latter studies showed that between 19 and 65 per cent of the SO_2 entering a convective storm in the updraft through the cloud base was removed and deposited in the precipitation.

The liquid water content of winter snow-producing clouds in Alberta is typically only one tenth of the value found in summertime cumulus. Thus the SO_2 scavenging efficiency would be expected to be very much lower on this basis alone. In addition, the oxidation rates of SO_2 would be much lower in the presence of ice crystals instead of cloud droplets, and at the much lower temperatures of wintertime clouds. These two factors thus account for the much lower value of sulphate found in snow as compared to rain.

Most of the mass of large hailstones comprises water accumulated in the cloud. Thus the sulphate contents found in hail are indicative of the values occurring in the liquid water in the cloud itself. Since the values of sulphate in the hail and rain collected in the same general area are similar, this is taken as further evidence that rainout rather than washout is the main mechanism for removal of SO_2 in Alberta in the summer months.

AN ATMOSPHERIC SULPHUR BUDGET FOR CENTRAL ALBERTA

The Sources of SO_2 in Central Alberta

The major sources of SO_2 in Alberta are the gas processing plants. The map in Fig. 4 shows the location of the plants in central Alberta and the average daily emission rates* of SO_2 over the period of 1 July 1969 to 30 June 1970. The total of all these sources in the map-area is 847 long tons per day. The largest concentration of sources is in the region of Crossfield and Didsbury with a total daily output of 518 long tons. The next largest sources are west of Calgary with an output of 84 long tons per day and northeast of Rimbey with an output of 62 long tons per day. The remaining smaller sources are scattered through the area.

Deposition of Sulphur from Precipitation

The location of all rain and hail samples collected for analysis is shown in Fig. 5, together with the content of sulphate. When more than one sample was collected at a location the average value over the whole time sequence is shown. Note that these sulphate contents are for only one sampling occasion at each location, and thus do not represent average values for the whole summer at each location. Isolines of equal sulphate content indicate the broad regional variations. It can be seen immediately that the two areas where the sulphate contents of rain are in excess of 4.0 mg/l are closely related to the regions of highest SO_2 emissions. Unfortunately, the only samples collected south of Didsbury were near the highway south to Calgary and so no information is available on the west to east variation of sulphate content in this area. However, there are enough data in the region near to, and east of, the Rimbey gas plant to make an estimate of the average deposition of sulphate. In the area around this plant the average content of sulphate from the convective storms of June to August is about 3.0 mg/l. This amount is higher than those quoted by Walker[3] for the same general area, but his data include the spring and fall showers which, because of their lower water content, would be less efficient in removing SO_2 from the atmosphere. The total rainfall in this area during the period June to August averages 10 inches (25 cm) giving a total deposition of sulphate of 2.5 kg/ha or 2.3 lb/acre during these three months.

Sulphur Budget for the Rimbey Area

From the data presented in the previous sections it is possible to determine an approximate sulphur budget of the atmosphere. The location of all the major sources of SO_2 are shown in Fig. 4 and the strength of the emissions are known fairly accurately. Unfortunately, the sulphate deposition rates are not nearly as well defined. The only data are those presented in this report and those given by Walker[3]. Figure 5 strongly suggests that a substantial fraction of the emitted sulphur is deposited close to the source. The map also suggests a tendency for high sulphate deposition northwest of the source. This is

*Data supplied by private communication from the Energy Resources Conservation Board, Calgary, Alberta.

Table 1. Components of the sulphur budget in the Rimbey area, Alberta

Season	Deposition of sulphur as sulphate			Emission of sulphur as SO_2 (E) 10^3 long tons	Fraction (D/E) of locally produced sulphur removed by precipitation %
	Average content of excess sulphate in precipitation mg/l	Average rainfall or rain equivalent in / cm	Local deposition (D) 10^3 long tons		
Summer (June-Aug)	2.0 to 3.0	10 / 25	0.9 to 1.3	2.8	32 to 46
Winter (Nov-Mar)	<0.5	4 / 10	<0.1	5.2	<2

related to the fact that the flow of the surface air feeding into most of the severe convective storms is from the southeast. In order to assess the amount of sulphur deposited close to the source we will consider only an area of radius 25 miles around Rimbey as shown in Figs. 4 and 5.

The total SO_2 production within this area averaged 66 long tons per day between 1 July 1969 and 30 June 1970 and was about the same during the previous two years. There is an annual cycle with winter gas production 10 to 15 per cent higher than in the summer. Thus for the purposes of calculation the emission of SO_2 will be taken as 62 long tons per day in the summer and 70 long tons per day in the winter.

The various components of the atmospheric sulphur budget are shown diagrammatically in Fig. 6 and some typical values of the main components in the Rimbey area are given in Table 1. According to Junge[4], approximately 0.5 mg/l of the sulphate in rain is due to the worldwide background and this value has been subtracted from the value in the second column of Table 1 to give the sulphate deposition due to local SO_2 sources only.

In snow, the contribution of sulphate from the worldwide background is not known but is probably less than that in rain for two reasons. First, the rainout or scavenging efficiency of snow is less than that for rain. Second, much of the snow in Alberta originates in arctic airmasses which originate in unpolluted areas and thus have a lower background level. The total average sulphate found in snow in central Alberta in this study, together with the data given by Walker[3], show that the sulphate contributed by local anthropogenic sources must be less than 0.5 mg/l in the area of the Rimbey plant.

The sulphur budget for the area around the Rimbey gas plant is given in Table 1 for the summer and winter months. Not enough data are available for the spring and fall months. The budget shows that in the summer months a considerable fraction of the SO_2 emitted from the Rimbey gas plant is oxidized and deposited as sulphate within a radius of 25 miles. In the winter months, snow deposits only a negligible amount of sulphate in this area.

SUMMARY AND CONCLUSIONS

The results presented here show that most of the sulphate found in rain and hail collected in central Alberta is of local industrial origin. The typical values of 2.0 to 4.0 mg/l of sulphate found in the convective rain are well above the natural background and approach the values in the moderately polluted areas in the United States and Europe[4,7], but are well below the heavily industrialized areas of these countries.

The amount of sulphate found in snow is very small and so close to that of the natural background that it is impossible to determine how much is of local origin.

From a sulphur budget in the area around the Rimbey plant it appears that a substantial fraction of the SO_2 emitted is oxidized and deposited as sulphate by the summer convective rains within a short distance of the source. The common characteristic of all summertime convective storms is a strong updraft core causing a localized high liquid-water content within these storms. The air containing SO_2 entering the cloud is moving up through this region of high liquid-water content in way analogous to the action of a gas scrubber in an effluent stack. The efficiency of this system in removing SO_2 is thus high. Furthermore, the air flux into the base of moderate to severe convective storms is between 5 and 30 km^3/min.[8] During the typical lifetime of 5 hrs one storm processes a volume of between 1500 and 9000 km^3 of air. The storm thus acts like a huge vacuum cleaner sucking in the surface layers of air containing the accumulated SO_2 over very large areas. Even though convective storms of this type occur on the average only every second day during the summer they are thus an effective means of cleansing the air of SO_2 in central Alberta. Unfortunately there are no data on sulphate content of precipitation over a wider area downwind of the sources but it appears that most of the SO_2 is removed before the air leaves Alberta.

The situation is very different in the winter. Snow occurs in stable air masses with very little vertical transport of the air. The SO_2 emissions are for the most part trapped in the lowest few thousand feet of the atmosphere and do not get a chance to enter into the precipitation mechanism, and thus very little of the SO_2 is removed by snow near the source. The eventual disposition of this SO_2 is unknown, but it probably travels a long distance from the source before being removed from the atmosphere and essentially becomes part of the background entering areas well downwind.

ACKNOWLEDGMENTS

The authors wish to thank the Energy Resources Conservation Board, and particularly Mr. G.A. Warne for supplying us with data on the average daily emission rates of SO_2 from gas processing plants in Alberta. The analytical determinations were carried out by Messrs. M. Strosher, D. Huber and A. Maskwa whom we sincerely thank for their assistance. This program could not have been carried through without the enthusiasm and cooperation of the Alberta Hail Studies Project mobile sampler operators.

REFERENCES

1. Renick, J.H. (Editor), "Alberta Hail Studies Field Program 1970", Research Council of Alberta, Hail Studies Rept. 70-1, 1970.

2. Egnér, H., Brodin, G., and Johansson, O., "Sampling Technique and Chemical Examination of Air and Precipitation", Kungl. Lantbrukshogskolans Annaler, 22, 369-410, 1956.

3. Walker, D.R., "Sulfur in Precipitation in Central Alberta", Can. J. Soil Sci., 49, 409-410, 1969.

4. Junge, C.E., Air Chemistry and Radioactivity, Academic Press, 1963.

5. Beilke, S. and Georgii, H.W., "Investigation on the Incorporation of Sulfur Dioxide into Fog and Rain Droplets", Tellus, 20, 435-441, 1968.

6. Summers, P.W., "Scavenging of SO_2 by Convective Storms", in Precipitation Scavenging (1970), 305-318, AEC Symposium Series No. 22, 1970.

7. Blokker, P.C., "The Atmospheric Chemistry and long-long-range Drift of Sulphur Dioxide", J. Inst. Petroleum (London), 56, No. 548, 71-79, 1970.

8. Auer, A.H. and J.D. Marwitz, "Estimates of the Air and Moisture Flux into Hailstorms on the High Plains", J. Appl. Meteor., 7, 196-198, 1968.

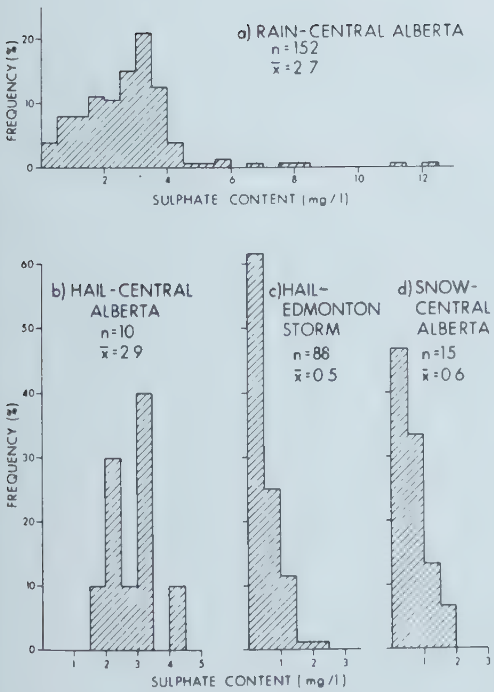


Fig. 1. Frequency distributions of sulphate content in:
a) Rain from central Alberta
b) Hail from central Alberta
c) Hail from the Edmonton storm 4 August 1969
d) Snow from central Alberta January 1969

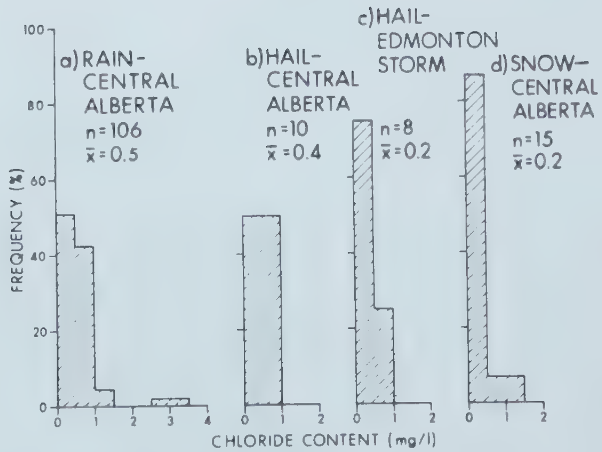


Fig. 2. Frequency distributions of chloride content in:
a) Rain from central Alberta
b) Hail from central Alberta
c) Hail from the Edmonton storm 4 August 1969
d) Snow from central Alberta January 1969

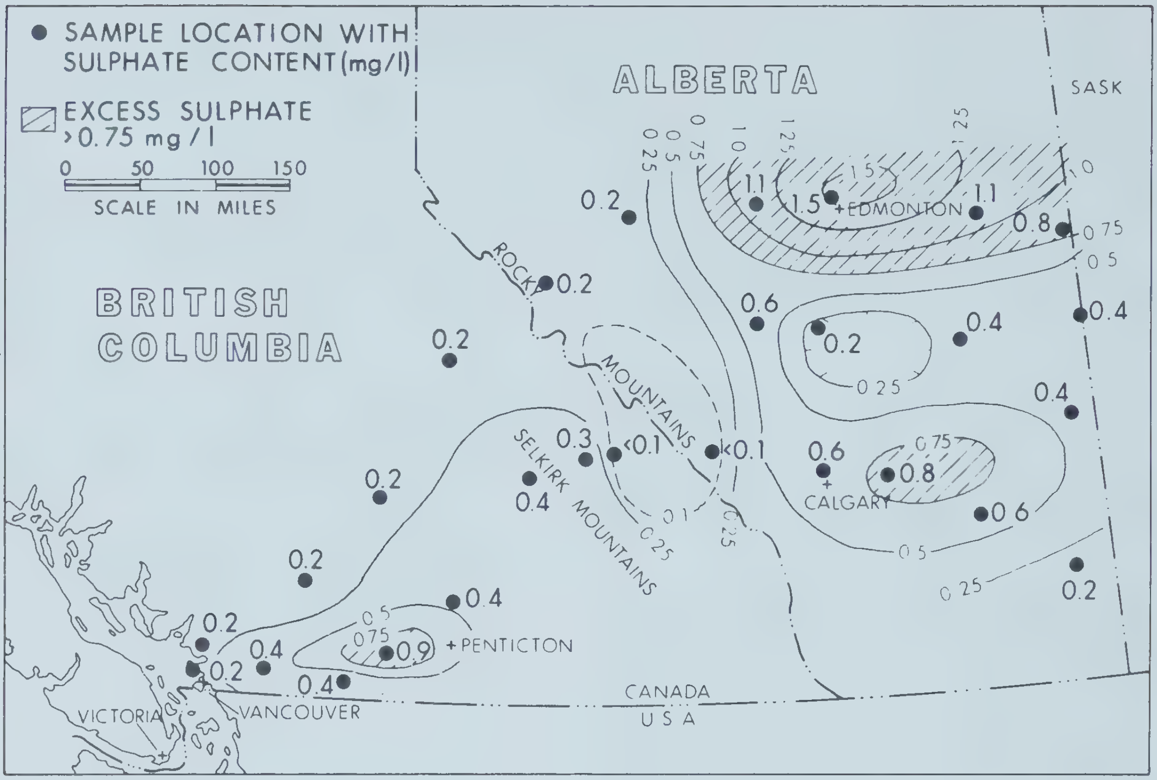


Fig. 3. Regional variation of excess sulphate content of snow from Alberta and British Columbia, collected in January 1969.

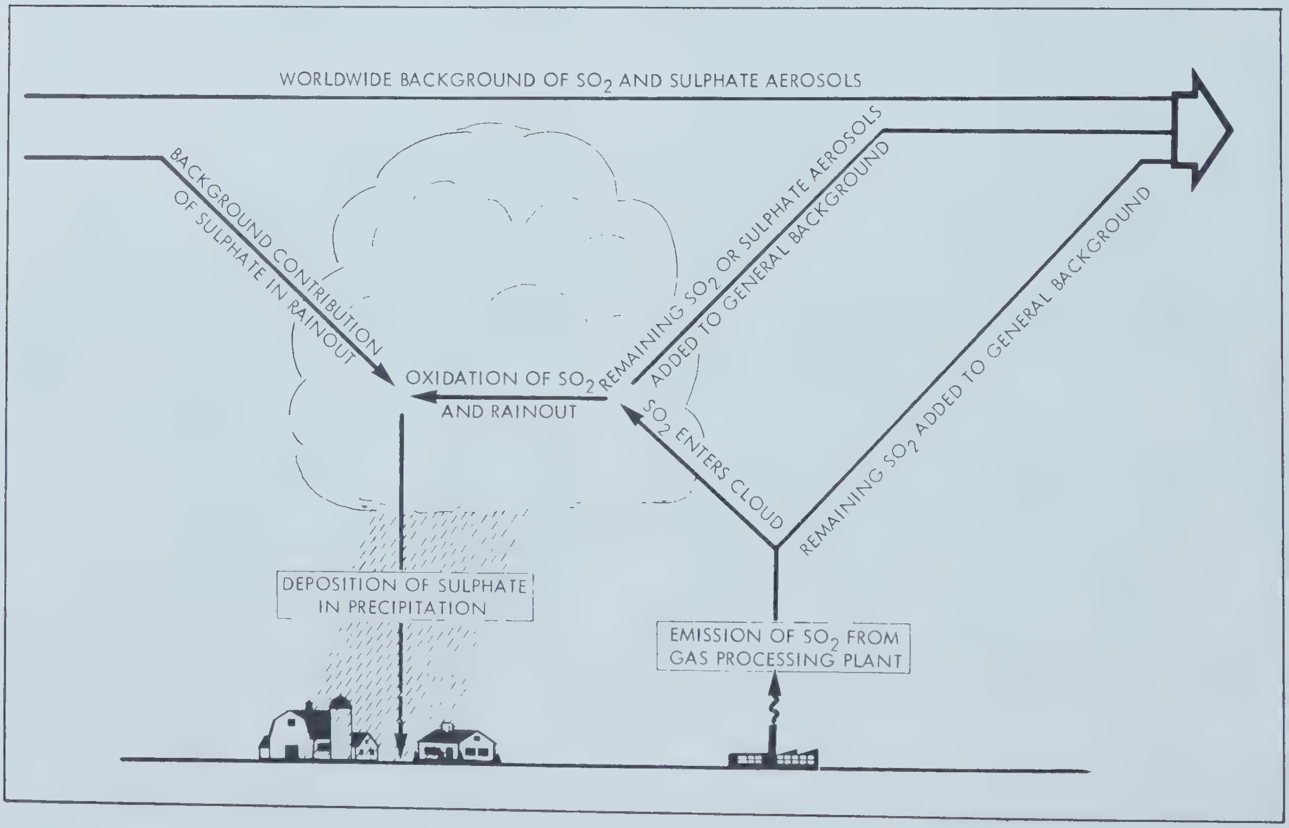


Fig. 6. Diagrammatic representation on the main components of the atmospheric sulphur budget for the Rimbey area.

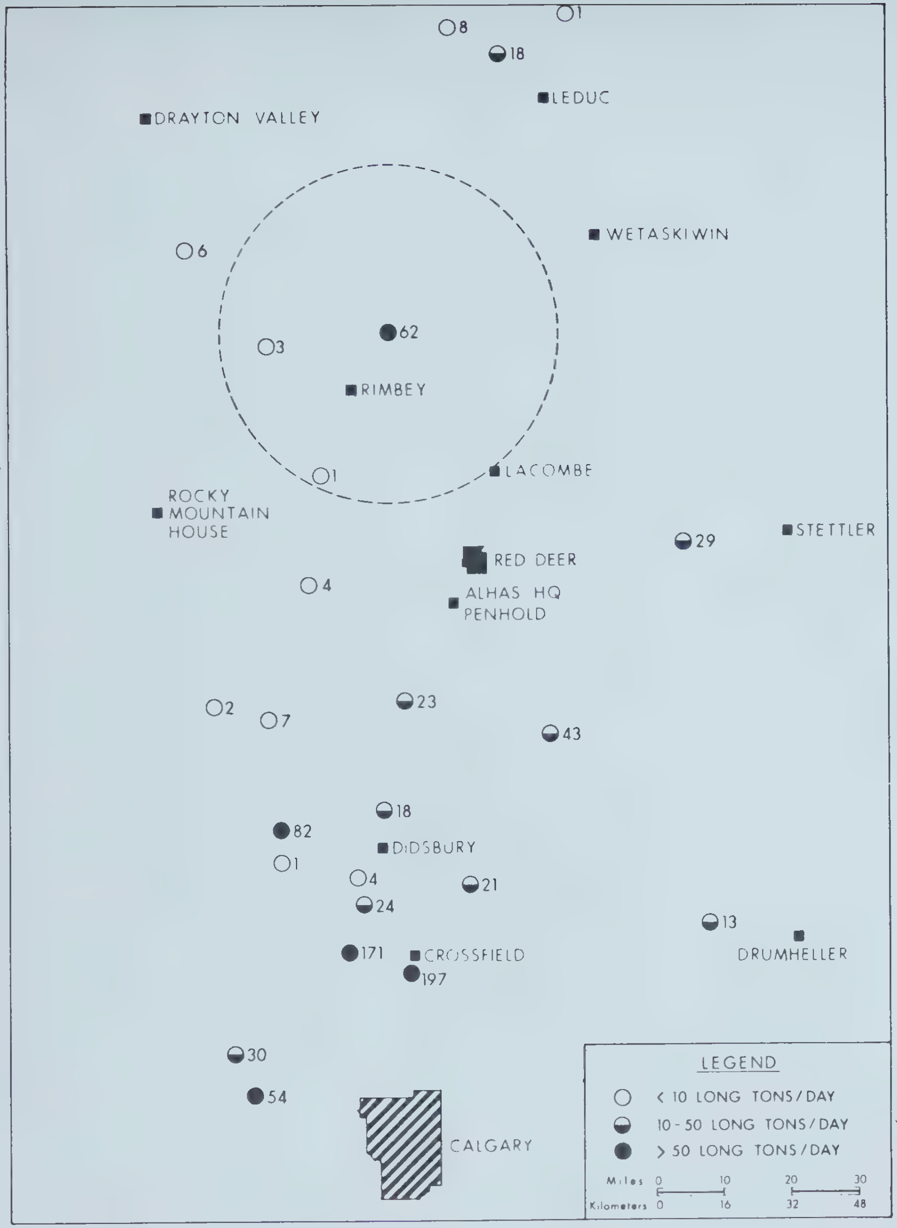


Fig. 4. Location of gas processing plants in central Alberta with the average daily emission rates of SO_2 for the period 1 July 1969 to 30 June 1970. Units are long tons per day.

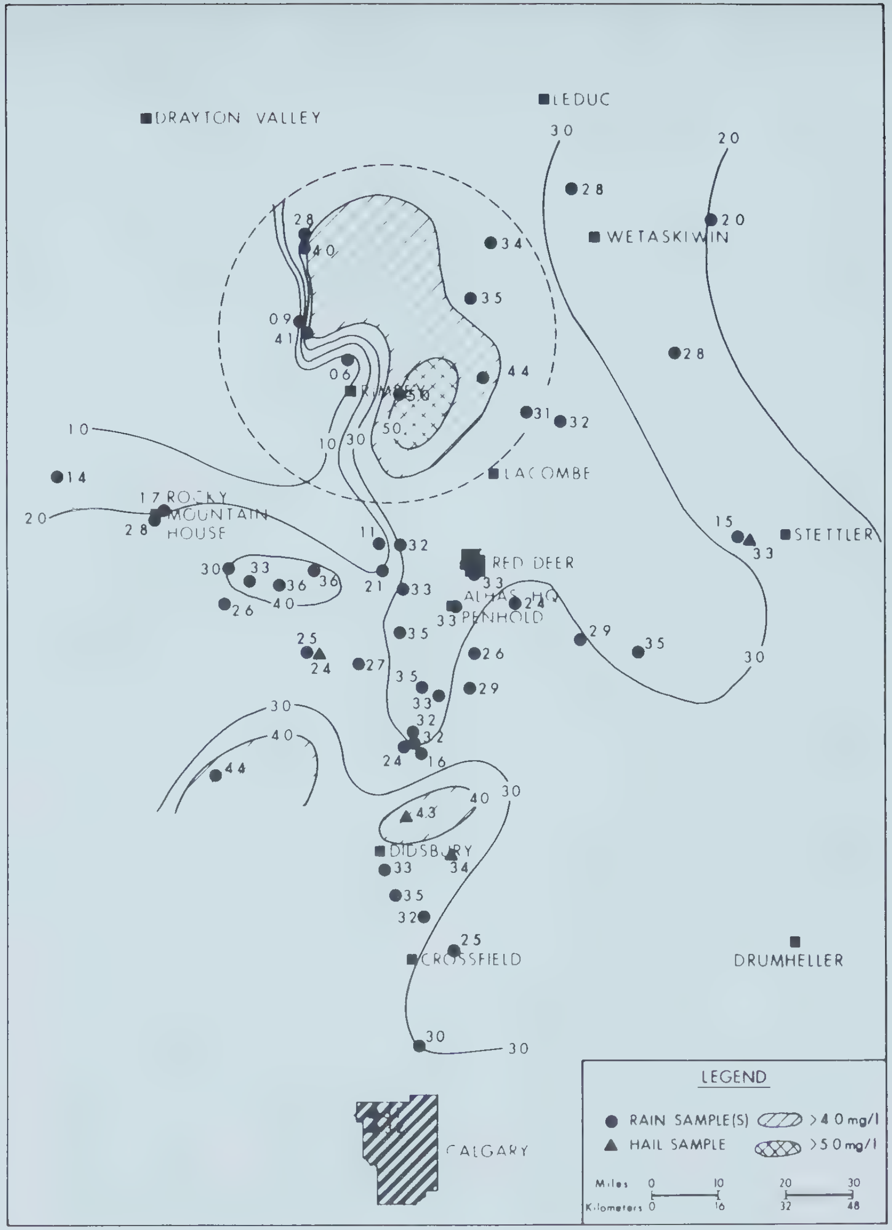


Fig. 5. Locations of samples of rain and hail collected in central Alberta, showing the mean sulphate content at each sampling location

QUESTIONING BY THE AUTHORITY

DR. S.B. SMITH

Is there an applied research effort of any consequence at the Research Council now with respect to new techniques and new technology important in SO_2 dispersion and the ultimate fate of SO_2; or is the SO_2 information you brought to us extracted from something else you were doing on the hail picture?

DR. P. SUMMERS

It was extracted from something else we were doing. The main emphasis of my group, of course, is in weather modification directed to hail control. If there are some inadvertent effects it is to our advantage to study them because it may be a means of control. As part of the hail study program in 1969 when we did have research instrumented aircraft up to take other measurements around the storms, there was room to put a sulphur dioxide analyzer on. At the present time this project is really secondary to our main aim and there is no real intensive effort in continuing this work that I have reported on.

DR. W.R. TROST

In the winter time we have cold temperatures and the gas comes out of the stack pot, mixed with water, sulphur dioxide and various componenets, suddenly exposed to a sharp drop in temperature. There are people who are concerned about it and wonder what happens under those conditions. Do you have knowledge of that?

DR. P. SUMMERS

I'm afraid I don't. Physical measurements in the atmosphere were made in the summer. The only measurements we made in the winter were sulphate concentrations in the snow on the ground. We made no other measurements in conjunction with that, so that anything we say about the winter is trictly inference from what we saw in the snow.

BRIEF

Presented to the ENVIRONMENT CONSERVATION AUTHORITY
PUBLIC HEARINGS ON THE ENVIRONMENTAL EFFECTS OF
SULPHUR EXTRACTION GAS PLANTS

by

P. A. BONNETT

for

THE INTERDISCIPLINARY COMMITTEE FOR ENVIRONMENTAL QUALITY,
UNIVERSITY OF ALBERTA, EDMONTON.

OCTOBER 1972

INTRODUCTION

The Interdisciplinary Committee for Environmental Quality comprises a group of people drawn from various disciplines at the University of Alberta with a common interest in environmental issues. Through interdisciplinary cooperation we hope to provide alternative solutions to some of the many problems our society faces today. We further believe that we have a responsibility to cooperate with other interested people in the community to both provide information and identify subjects in need of research. To this end we offer our contribution to this public hearing.

AVAILABILITY OF INFORMATION

a. We are pleased to see the report prepared for the Environment Conservation Authority by Dr. Klemm but find the date of release to be very unsatisfactory if this document was meant to provide information to those participating in the hearings. Our copy reached us on September 25th and we have no reason to believe that it had been unduly delayed. Thus for people presenting briefs to the first hearing in Pincher Creek this report would have been too late to help them in preparing their material. If it is the purpose of these hearings to receive input from all sectors of the public then the most disadvantaged would be individuals who did not have access to the information in sufficient time. We presume that industry would have its own resources and information upon which to base its submissions. We regret that this is not the first time that we have had to criticise the Authority on this particular issue.

b. On reading the report we were surprised to see in the Foreward an acknowledgment that the 'material in this report has been released with the approval of the Government of Alberta' . We did not recall a similar certification appearing in previous Environment Conservation Authority reports. We therefore are led to wonder if other material which has not been approved has yet to be disclosed. On looking closely at the document one is tempted to believe that this is indeed the case for on page 88 we note an incomplete sentence and on other pages, particularly 36, 39, 82 and 83 there are inexplicable blank spaces. We must either fault the editors on their extremely poor style or conclude that information has been excised and thus removed from public scrutiny.

c. Analysing the report we were disturbed to discover that the contents belied the title to some extent. There is quite properly an emphasis on the technical aspects of the industry but the general thrust of the material is to give an account of the economic rather than the environmental impact of the industry. We therefore assume that this reflects the lack of data and information on this aspect, which we would venture to suggest is a shortcoming in need of immediate remedy. It appears to be the case that we have not developed adequate tools with which to measure the social costs of resource development and thus the background report is deficient in its description of the total impact on human and other biological systems.

d. We observe that one consultant was retained to compile the report and we would suggest that we can no longer expect a single 'expert' to encompass a sufficiently broad range of knowledge to adequately document all aspects of a complex environmental problem such as the one we are considering here. In future we hope that the Authority will commission a group of suitably qualified specialists to provide an all round picture of the effects of any resource exploitation. To exemplify the shortcomings in this instance it is our understanding that considerable knowledge of particular case histories is available in at least one locality of Alberta and we had anticipated that these materials would have been collected and analysed by people such as doctors, veterinarians, meteorologists, plant physiologists and chemical engineers among others.

e. A surprising ommission from the report is any recommendations since we have come to expect these from earlier Authority publications. These have always provided stimulation for public comment at the hearings and we believe that a consultant is in possession of evidence unavailable to the general public and thus best able to make suggestions for improving upon the existing conditions.

f. The word 'environment' is widely used and probably means different things to different people but we had hoped that the Environment Conservation Authority would use a broad definition of the term recognizing that we are dealing with the total human environment. This includes more that the purely physical surroundings and particularly when we are considering the impact of man's activities we should include all possible components of the biosphere. Had the Authority adopted this broader perspective we suggest that we would not have had to make the criticisms in c and d above.

g. Finally we firmly believe that public hearings should provide a forum in which all people concerned with a particular issue may be heard. The public is very much interested in the activities of government agencies engaged in environmental management; it would be useful and educational for all concerned if knowledgeable personnel were on hand to explain and amplify on points relating to such matters as establishment of standards and enforcement of regulations to control pollution. The failure of officials to appear at these hearings serves only to perpetuate the bewilderment and distrust displayed by the lay public toward the government. We would like to suggest that the government consider the positive value which might derive from the input of civil servants at these hearings.

ENVIRONMENTAL COSTS

a. It is increasingly necessary that our society in conserving natural resources adopts a broader viewpoint when calculating the cost of extraction and development of any resource. The external costs particularly as these affect communally owned resources must be brought into the calculus and reflected in the final price to the consumer as it is only in this way that the market mechanism can be effective. In respect to the externalities

associated with the operation of sulfur extraction gas plants we refer you to a short paper prepared by members of the Interdisciplinary Committee for Environmental Quality and included here as Appendix 1.

b. We are aware of the philosophy propounded by the Honorable W. J. Yurko, Minister of Environment, that the "Polluter should pay" and we agree with the principle. However, there are certain consequences from the acceptance of this idea and it is here that we find much to disquiet us. In order to implement the concept it is first necessary to fully understand the impact of a given activity on the total environment. Without the appropriate research and careful study both prior to the commencement of an activity and during its operational life, we believe that the environmental impact cannot be assessed and thus the true costs can never be equitably assigned.

c. When considering the "real" economic value of the natural gas industry in Alberta, it is instructive to glance at the names of the companies involved. It appears that a high proportion of the profits do not remain within the province or indeed in Canada. It is often claimed that the number of jobs created makes such resource industry an essential part of the provincial economy but while it is true that the construction industry benefits the final number of permanent jobs is believed to be some 5000 in gas plants. Before reaching the conclusion that this is quite satisfactory the ownership of the construction companies should be considered and also the working environment within the gas plants. An evaluation of the total economic situation with all social costs included might reveal a less than acceptable picture of the natural gas extraction industry.

POLLUTION FROM GAS PLANTS - FACT OR FICTION?

a. In the Pincher Creek area of Alberta there have been since the late 1950's a group of people who believe they have been exposed to pollution caused by two sulfur extraction gas plants. These ranchers are convinced that the problem is both real and important but objective evidence is not easy to find. Nevertheless, when the various statements, reports and facts are assembled it is hard to accept that there is no environmental impact from the sour gas plants.

We find the attitudes and the behaviour of ranchers in the commencement of legal proceedings indicates that they perceive the problems as important and not imaginary. Similarly the human symptoms reported from the sour gas areas are in most cases not uncommon and might well be psychosomatically induced. However, they are also characteristic of the initial stages of intoxication by a wide range of compounds. Complaints are therefore consistent with toxicity due to environmental contamination but not diagnostic. Since no study of a control group has been made we are unable to form a definite opinion as to the reported symptoms.

We have been unable to assure ourselves that an adequate evaluation has been carried out to explain the numerous cases of livestock mortality and morbidity in the vicinity of sour gas plants. Thus it seems impossible to state unequivocally that pollution exists but it is equally unreasonable, on the basis of the available information, to say that all complaints are a fiction (See A ppendix 2).

THE DISADVANTAGED LAYMAN

a. The ordinary person, the so called 'man in the street' is still relatively unaware of his reciprocal relationships with his environment. He also is unlikely to be familiar with technical details of industrial processes. Furthermore, the ordinary person is without large financial resources or access to a variety of experts such as environmental consultants and lawyers. In sum he is not well equipped to undertake research over a long period of time; to collect and analyse information so as to prove that his health or property is being damaged. Yet over the last decade in Alberta this is the demand which society has placed upon the individual who believes himself damaged by resource exploitation. The onus is on the lay public to prove that they have been harmed. The inequity of this situation has been well illustrated by the sufferings among the ranching community in the Waterton sour gas field who have been forced to fight two multi-national corporations with presumably large resources, in an effort to obtain recompense for the disruption of their lives following the location of two sulfur extraction gas plants. These people were unprepared and unable to undertake the necessary documentation of scientific facts which would have enabled them to substantiate their claims. In the early days they did not have access to scientists who could have aided them in their plight. Their case was in no way aided by the attitudes and response of government officials who since the first complaints were voiced in the 50's, persisted in taking the position of disproving the ranchers claims. At no time has it been obvious to the public, that officials have required industry to prove, without reasonable doubt, that they were causing no damage to the human environment.

b. If we look at the briefs presented to the earlier hearings in this series it is evident that individuals are even now suffering harm which they attribute to the operation of the sour gas plants. While our attention has been focused on the case in Pincher Creek we now wonder if a more serious situation may not exist in Central Alberta where the number of plants is greater and also the exposed human population is larger.

c. From Dr. Klemm's report it seems clear that the fate of the plant worker is even less certain than that of those residing in the vicinity of plants. With allowable levels of exposure to gases as high as indicated in the report and very little evidence to confirm that no

chronic effects result from such conditions we suggest that the worker is in urgent need of further consideration. Information should be sought upon the following aspects:- The medical record of men who have worked in the industry for twenty years or more. The results of research conducted to ascertain the chronic effects of daily, low level exposure to sulfur compounds.

If neither the industry nor the government agencies can provide these facts then we would suggest that a project be commenced immediately to remedy the omission.

REGULATORY AGENCIES

a. We note from the background report that recent changes in legislation have brought the establishment of emission standards under the ultimate control of the Minister of Environment and we applaud this action. We have in the past, been worried by the fact that the Energy Resources Conservation Board has been required to both devise the standards and guidelines and enforce compliance with them. Our concern has arisen from the apparently close relationship which the Board enjoys with the industry it has to regulate. We therefore believe that the Board may not always be in a position to take an objective viewpoint and act in the best interests of the public at large. We therefore reiterate our approval of the new arrangements but still are unsure that all problems have been alleviated. For example we wonder who is now responsible for commissioning or conducting the necessary investigations to develop new standards in controlling emissions and effluent discharge. If such a task is not part of the Minister's role is it left to the Board to make these important decisions and if so who actually conducts the research?

MONITORING OF ENVIRONMENTAL IMPACT

a. The report prepared by Dr. Klemm adequately reflects the complexity of the technological processes involved in sulfur extraction gas plants and suggests the potentially large number of contaminants. By comparison the monitoring system for materials emitted from the plant to its surroundings is seen to be of a simple form concentrating as it does upon inorganic sulfur compounds in emissions to the atmosphere and on a small number of easily measured parameters in the effluent to the watercourses.

b. We find confusing the multi-jurisdictional monitoring of the total plant environment, both internal and external. The responsibility for checking the ambient air and water quality in the vicinity of gas plants rests with the Department of Environment while that for the source monitoring rests with the Energy Resources Conservation B oard. The internal monitoring to protect the health of plant workers is presumably the role of the Department of Health and S ocial Development. We are unable to determine whether this situation is satisfactory but it clearly

has the potential for producing confusion and consequently may be deficient in ensuring that adequate standards of environmental quality are maintained in and around the gas plants.

c. In respect to the monitoring of compounds exhausted from gas plants we noted that each operator is required to send the Energy Resources Conservation Board a monthly summary of all data. If the principal reason for insisting on this procedure is to better police the compliance of the operator with the emission approvals, we believe that it leaves something to be desired, since it cannot provide preventative control. The Board is informed after the event, that a violation of approved levels has occurred and is thus in no way able to prevent damage to people, crops or wildlife that such an event might occasion. The existing approval and monitoring procedures are retrospective and in need of further improvement.

d. We wish to draw the attention of the Authority to the deficiencies in the monitoring conducted to date by the provincial government. We find that the range of substances and elements which are regularly monitored is too limited and the frequency of measurement leaves much to be desired. The inability to measure episodic occurrences when high concentrations may be present has severely restricted the credibility of much of the monitoring data. In the case of the gas plants where in addition to the emissions from the plant itself there may be other sources of potentially dangerous substances such as wells, battteries and pipelines we find it hard to understand why no mobile equipment has been devised to measure ambient quality of the environment. The mobile trailers used by the government are restricted both in their capacity to measure a range of compounds and in their location, since they require a source of electricity. From the information we have been able to obtain, the manner in which these trailers collect their samples is inflexible when one considers the number of complaints of noxious gases trapped in low-lying areas. It is our understanding that the intake pipe on the trailer is some ten feet in the air.

Due to the lack of sophistication in our technology we are still unable to measure any interactions between contaminants and thus to make statements on the lack of toxicity of separately measured compounds because of their apparent low level of concentration, is to mis-interpret the data.

LACK OF INTEGRATED RESEARCH

a. From our knowledge of the problems in the Pincher Creek district of Alberta we are aware that there has been an insufficient effort on the part of the government to ensure an integrated approach to discovering the cause of certain unexplained environmental problems. Knowledge of the basic principles of ecology reveals that in dealing with biological systems we are considering complex systems. A feature of such systems is the lack of obvious relationship between cause and effect. It is commonly found that cause and effect are separated both

in time and place, thus to expect to find readily available answers to explain unanticipated events arising from the introduction of a sulfur gas plant to an area is to display an ignorance of the fundamental mechanisms of the biosphere.

FURTHER INVESTIGATIONS

a. We are of the opinion that the public hearings will only scratch the surface of what may be a very widespread problem since many individuals are often reluctant to appear in public and state their views. We therefore submit that a need exists for a thorough community survey. A field survey of all the gas plant areas in the province should be made to collect data and information from residents, professionals and industry personnel on past histories of any environmental disturbance. The purpose of such a project would be the identification of certain patterns of response in the localities of sulfur extraction gas plants. Included in the survey should be the sweet gas plants to establish that these are as innocuous as is believed to be the case.

b. Livestock from sour gas areas should be purchased and thoroughly examined. Autopsy reports on animals that lived adjacent to plants should be examined to determine whether any unusual pathology was noted. A concurrent study of plant pathology should be conducted.

c. A series of monitoring surveys to examine gas plants for additional contaminants should be conducted if the above mentioned surveys reveal some repeated patterns of effect around sour gas plants. Continuous monitoring for a one year period should be used and the data so obtained should not be open to criticism on methodological grounds. Materials balance studies for a sample of individual gas plants should be instituted with the purpose of identifying the complete range of elements which might be present in effluent streams to the air and water.

d. It should be noted that the studies as indicated above would obviously be expensive but they could be expected to reveal an answer to the question "How much environmental contamination occurs due to gas plant operations?" . If new gas plants are to be constructed, existing ones modified and expanded and there is to be continuing operation of plants for some twenty years then it is the responsibility of the provincial government to establish whether pollution problems are fact or fiction. Incomplete attempts as we have seen so far will only waste both time and money. It is up to the government to decide between calling a halt to all further investigations or initiating a sufficiently comprehensive project that will provide enough information to make it possible to decide whether or not the problems are directly attributable to sour gas plants.

e. In all newly initiated studies we strongly advocate the "team approach" to better ensure the completeness of the data and the determination of the causal factors involved in the environmental problem.

THE FUTURE

It appears to have taken 15 - 20 years for one aspect of sulfur extraction gas plant impact to be effectively controlled. We have yet to find out if there are contaminants other than the obvious inorganic sulfur compounds. People who reside in the vicinity of these plants are still complaining of environmental disturbance and disruption of their normal life pattern. It is clear that we have merely revealed the tip of the iceberg in our assessment of the environmental impact of the sulfur gas extraction industry.

We must proceed with complete, ecological surveys to determine the total range of possible contaminants as indicated by Dr. Klemm's report. Furthermore we have to recognise that there are first, second and third order perturbations which should be investigated if we are to answer some of the questions raised by situations such as have emerged in the Pincher Creek area.

There is a lesson to be learned. Before exploiting new resources there must be investigations of the environmental impact and the public should be given information to allow them to assure themselves that the economic advantages do sufficiently outweigh the environmental costs:

Research on a materials balance approach should be commenced and in future the onus of proof has to be transferred from the shoulders of the private citizen to the corporate body wishing to exploit a given resource.

We leave the Authority with some questions. What is being done in respect to the imminent 'explosion' of resource exploitation in the Athabasca Tar Sands? Will we see again the same set of circumstances as we have witnessed in twenty years of natural gas extraction? Can we afford to let it happen again? On behalf of the public we request that the provincial government recognises its responsibility to consider not only the economic health of Albertans but also their personal health. We in Alberta are fortunate in possessing so much of the world's limited supply of fossil fuel and for this reason we should also be aware that we must show maturity and responsibility in managing these scarce resources so as not to irretrievably disturb the functioning of the biosphere.

APPENDICES 1 and 2

APPENDIX I

gas-processing plants and the environment — who pays the bill?

—P. A. Bonnett and
Don Gill

The social costs of resource extraction and refining processes have always existed but only recently have they been recognized and we have yet to find appropriate ways of incorporating them in the price paid by the consumer for the final product. The nature of these costs is one of hidden disbenefits — hidden, that is, to the average person who creates the market demand for a given product. In essence these costs, or "externalities", to use the terminology of the economist, result from industrial activity which may often produce side effects remote in time or distance from the source of the activity.

In our province we have been tapping the natural gas resources for three decades and many of us enjoy the benefits of this relatively clean fuel for our domestic heating systems. Access to this fuel also results in less pollution from the gas-fired power stations allowing many citizens to experience much less polluted air conditions than would be the case if coal was widely used. A feature of the natural gas found beneath the surface of this province is its high content of sulphur which requires that it be processed to remove this contaminant prior to sale for public consumption. Gas processing plants may be found in many parts of Alberta particularly in the southern half of the province.

It was in 1969 that the authors first became acquainted with some environmental problems associated with the extraction and processing of natural gas. Here it seems is an instance where the full social costs of a particular industry are not being fully reckoned or incorporated in the price we pay for the gas piped into our homes. There is a likelihood that health hazards exist in the vicinity of gas processing plants and these have never been fully investigated nor have their associated costs been weighed. A recently announced public hearing to be conducted by the Environment Conservation Authority this autumn may go some way toward filling this gap in our knowledge and perhaps alleviating some hardships suffered by people residing in gas field areas.

A brief resume of problems experienced by ranchers in the Pincher Creek district will serve to indicate the extent of the human problems involved in exploiting the gas resource. A more extended version of this report may be found in the document entitled "Environmental Pollution in the Drywood Creek Region of Southern Alberta: a Brief Submitted to the Alberta Department of the Environment" by M. Stick, P. Bonnett and Don Gill, Department of Geography, University of Alberta, November, 1971 (available from the Environment Conservation Authority, 9912 107th St., Edmonton).

In the late 1940's, commercial quantities of natural gas were proven in the Waterton-Twin Butte ranching area of the Municipal District of Pincher Creek (see map). By 1957, the British American Oil Company (later Gulf Oil Ltd.) had established a plant to process gas and extract 50,000 gallons of propane and butane and 675 long tons of sulfur per day. Shell Canada established their plant in the far more productive western field. Operations commenced in 1962, producing 6.500 barrels of pentanes and 1,000 long tons of sulfur per day, with a design capacity of 8,000 barrels of pentanes and 1,500 long tons of sulfur per day.

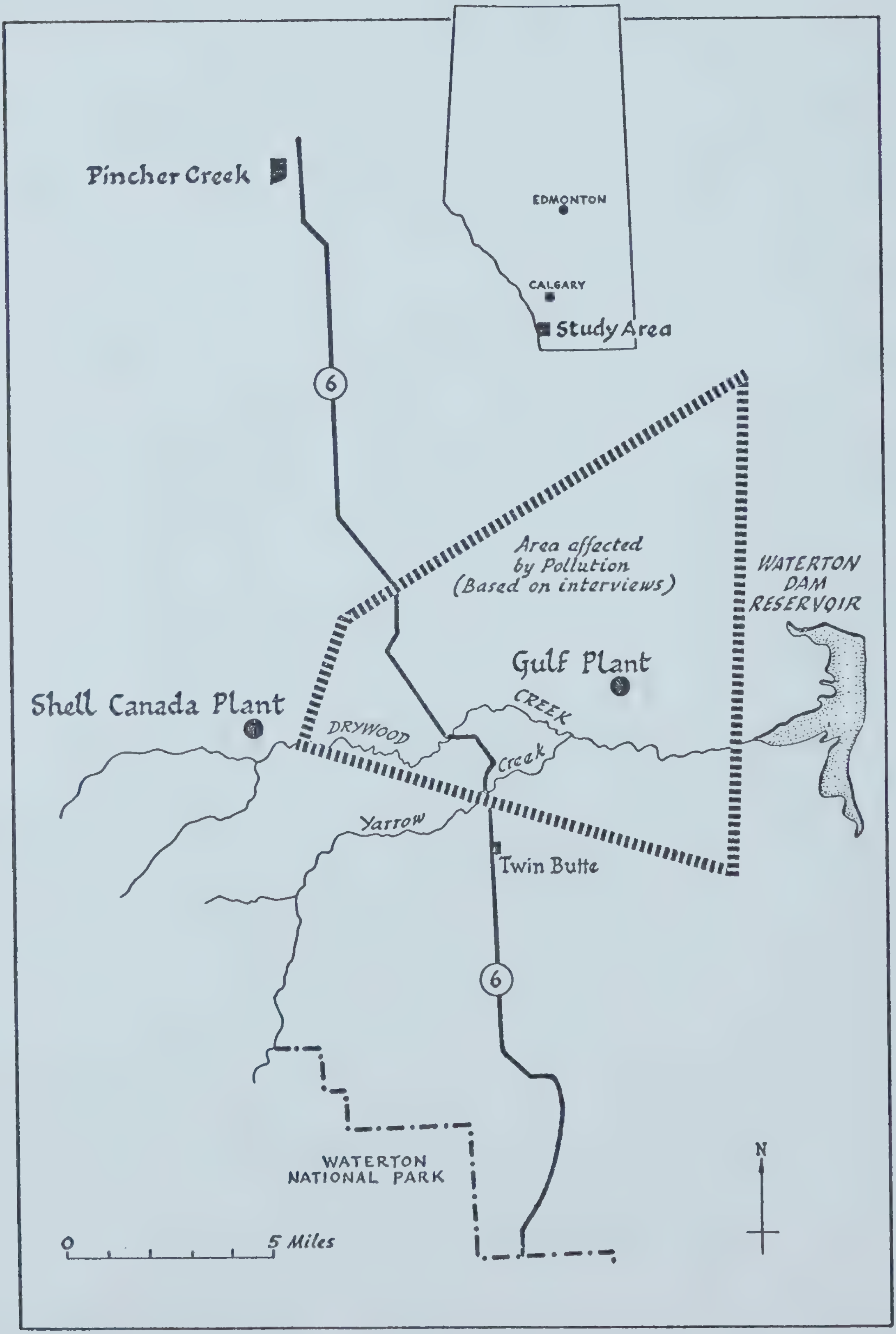
With the commencement of production of the plants, some forty ranching families in the vicinity began to complain of discomfort from gas fumes; several individuals experienced recurrent illnesses which they attributed to concentrations of noxious gases originating from the gas plants. Livestock production at this time was similarly affected and there were reports of damage to property and machinery. Ranchers' complaints to Alberta Provincial Government authorities and to the companies were investigated and eventually dismissed as hysteria. In late 1966, incensed at what they considered to be unfair treatment at the hands of government and industry, some of the ranchers instituted legal proceedings to gain compensation for what they claimed was the unnatural way they had to operate land which had been in their families for up to three generations. After five years, this lawsuit was terminated by the action of the oil companies who purchased an easement to continue the release of gas over the property of those ranchers who agreed to this procedure. Shell Canada Ltd. has consented to provide data to the ranchers in order that a check may be kept on the air pollution levels in the future. Some twenty-five to thirty families, however, who were not involved in this lawsuit, remain uncompensated, and in their view the pollution problem continues unabated.

In 1968, a second element of the pollution problem arose when members of two families in the area lere found to be suffering from lead poisoning and traces of lead were found in wells, springs and streams. Industry disclaimed any responsibility for the water pollution and governmental investigations found no proof that water contamination existed.

The health problems experienced by ranchers since the establishment of the gas plants have never been adequately documented but include common ailments such as headache, insomnia, skin, throat and eye irritation, stomach cramps, lassitude, nausea, nosebleeds and diarrhea. Other less common ills have also been experienced, including loss of appetite, anaemia, loss of the sense of balance, no weight gain in children, loss of kidneys (one male in mid-thirties), complete debilitation, temporary and permanent losses of vision, loss of speech, temporary paralysis, loss of normal movement (one male in mid-thirties), and severe allergy to domestic water supplies in the form of nausea and swelling.

Local doctors have been reported as saying that many of these symptoms are quite prevalent throughout southern Alberta and thus should not be attributed to effects of sulphur gas processing. This of course may be correct, but until an appropriate survey is conducted it is not reasonable to dismiss the complaints as purely psychosomatic, since the effects of gas plant operation upon the mental health of the local residents seems to have been quite detrimental. When people come to believe that they are being subjected to environmental contamination, and frequently experience symptoms of ill health, they should not be dismissed as cranks or hysterics. Whether or not the building of the two gas processing plants in the Drywood Creek valley has actually contaminated the environment is still to be determined, but there can be no doubt that the attitudes of many current and former residents have been dramatically changed toward this type of operation in the last fifteen years.

APPENDIX I



Pincher Creek
EDMONTON
CALGARY
Study Area
6
Area affected by Pollution (Based on interviews)
WATERTON DAM RESERVOIR
Gulf Plant
Shell Canada Plant
DRYWOOD
CREEK
Creek
Yarrow
Twin Butte
6
WATERTON NATIONAL PARK
0
5 Miles
N

APPENDIX I

In addition to the perceived damage to their own health, residents also maintain that air pollution accelerates corrosion of paintwork on buildings and machinery. They believe that there is occasional damage to vegetation and many ranchers attribute loss of livestock to the inhalation of fumes discharged from the stack of the processing plant.

The high degree of concern shown by families in localities close to the processing plants has produced two kinds of behavioral response. Some have become so wearied of the perpetual health problems that they have left their land and moved to the town of Pincher Creek or other locations and now travel back and forth to farm the land and tend their animals. Others have stayed and are still experiencing a variety of afflictions although some admit that things are improving because the industry has been cleaning up its operation in the last five years. There are still reports of cattle dying in mysterious circumstances and individuals suffering a variety of discomforts after drinking water from a well which in the past provided palatable drinking water.

When the question of the government's role in protecting the public from environmental contamination is raised, feelings among the affected ranchers run quite high. Over the last decade they have developed a hostility toward government officials who have tended to dismiss their complaints because the causes were not immediately obvious. From the evidence available in government files it seems that numerous public complaints have been investigated and generally shown to be trivial or erroneous. Regular monitoring of air and water quality in the vicinity of the gas processing plants was instituted but has been limited in the range of compounds checked. A general response by the government has been to conduct ad hoc studies over short periods of time which have discredited the ranchers' complaints and accusations. This has undoubtedly harmed the relationship of the two parties and explains the generally hostile attitudes prevalent in the ranching community toward the government. A widely held belief in the Drywood Creek area is that economic considerations have caused the government in the past to listen more closely to the claims of the gas industry (that no pollution problems are caused by their plants) than to listen to the pollution problems claimed by the ranchers.

To an outsider going to the district for the first time certain aspects of the area stand out. First, there is the odour near the gas plants; at first acquaintance it would appear difficult to work in the area for any length of time, or to reside nearby. However, one's nose gradually ceases to detect this odour since olfactory fatigue develops rather rapidly in humans. Visually there are few signs of pollution except along the railroad where a sprinkling of sulphur dust lines the track where it has fallen from the open cars. A walk along Drywood Creek provides little visual evidence of water contamination beyond algal growth below the outfall from the plant. There is little obvious evidence of damage to natural or planted vegetation.

Our knowledge of environmental contaminants is steadily growing and it is generally true that most pollution is **not** visible, indeed the more insidious pollutants are often undetectable to our senses. It is thus necessary to take a sophisticated approach and recognize that we are dealing with a complex system into which we have introduced a completely new element (i.e., a gas plant) which may have set in train a whole series of perturbations, some of which may be giving rise to the symptoms experienced by the ranchers of the Drywood Creek region. The response of industry and government in the past has been to rebut accusations of local residents in this area and to prove (not always conclusively) that there is little substance in their fears. To date there have been no real attempts made to positively allay the ranchers' concern by conducting a comprehensive survey to explain the apparent health problems.

As residents of this province we find much to disquiet us when we listen to the story of those residing in the gas plant area, and we are disheartened by the attitudes displayed by the civil servants charged with investigating these complaints. With the announcement of the public hearings this autumn, we hope to see a recognition that mental health is quite as important as physical health. When a small group of people feel disadvantaged by the operations of a large, financially powerful, multinational company, there should not be an automatic assumption that they are trouble-makers or hypersensitive invalids.

What is now required is a thorough ecological study to determine the changes in the environment wrought by the establishment of gas processing plants. The elements of such a study include an epidemiological investigation to determine the frequency and areal distribution of the several ailments commonly experienced by the ranchers. An input-output study of the plants should be made to determine what materials are released into the surrounding area. Such an investigation should not be limited to the most obvious materials such as sulphur and hydrocarbons but should also consider various heavy metals and compounds chemically similar to sulphur.

Such an investigation would be expensive but in view of the number of plants throughout the province the problem deserves intensive research if the well-being of citizens are threatened. At the present time some undetermined level of social costs are being borne by a very few people who had the misfortune to reside on land under which gas reserves exist. The reader is left to ponder the justice of this situation and perhaps to question this cost which should be rightly shared by all who use natural gas.

APPENDIX 2

To our knowledge the following events and complaints recorded by the ranching community in the Pincher Creek area, have never been satisfactorily explained nor viewed in an ecological framework to assess the possible interactions and synergistic effects which might be occurring.

1. Noxious and nauseating gases entering houses in the night.

2. Collection of unknown gas in depressions of fields which has rendered people unconscious and left livestock foaming at the mouth and partially paralysed.

3. Reports of loss of skin from exposed areas of the body following light rain showers.

4. A number of serious ailments and loss of functionof different organs. The confidentiality of medical records has made it impossible to have available for public scrutiny the total record of human suffering in the vicinity of gas plants.

5. Numerous reports of livestock dying in conditions of apparent paralysis, experiencing temporary blindness and lachrymation.

QUESTIONING BY THE AUTHORITY

DR. S.B. SMITH

Although you are critical of certain aspects of the Hearings do you support the general method and approach; and secondly, do you think that we have gone far enough? Would you advocate legislation requiring environmental impact statements and/or hearings?

MS. P. BONNETT

The public hearing is a useful procedure otherwise we wouldn't all be gathered in this room we wouldn't be exchanging this amount of information, we wouldn't have prompted perhaps the industries to come out in the force that they have in these five hearings and reveal some of this information. What I suppose I am querying is, could it be made more useful by having more two-way flow in it, perhaps the more tribunal type atmosphere? In respect to your question about environmental impact statements,you will be aware that in the U.S. they have indeed got this kind of legislation. I am unconvinced myself as to whether we need it, because I haven't really looked at it closely to consider whether the sort of administrative load that is imposed by this kind of requirement justifies the result. I would certainly think that we should consider it, and look at the American experience and see whether it is relevant.

DR. S.B. SMITH

The E.P.A. has had several thousands of impact statements presented to several dozens of civil servants in the past couple dozen months . I just wonder whether our approach here, which does not reside anywhere in legislation in Canada; but as a matter of policy. Are we approaching it in a more productive manner?

MS. P. BONNETT

I am unsure because, like you, I have seen some of these documents where they list the environmental impact statements and I'm sure they didn't really hire all the appropriate staff when they started this thing going and I would imagine they are completely snowed under. There are, therefore, certain impracticalities about this. Maybe it is still worth looking at and trying to find another procedure.

I really am not prepared to throw it out because I haven't studied it beyond knowing that it seems quite a burden on the civil servants.

DR. W.R. TROST

"The Disadvantaged Layman", I think you are catching on an important point that has a kind of structural inevitability about it, and you described it well, I am not too sure that you have actually come up with a very helpful recommendation. Do you want to elaborate a little bit on what I think is a very difficult question?

MS. P. BONNETT

I suspect that we are talking about legal mechanisms; and as Mr. Geddes pointed out, our final resort is to go to him and he will fight our case. That particular case started in '66 and it was settled last year; and there is no rapid solution. In the meantime people are being affected and some of them are obviously suffering damage, not just psychosomatic damage -- well, maybe it is psychosomatically induced in some cases, but certainly there is obvious physical damage there. I would certainly like to think that as society has reached a point in time where we are worrying about these things, we should be looking for an effective way of protecting the individual. I have no pat answers, but I would like to think that there were quite a few people actually studying this carefully.

National and Provincial Parks Association of Canada

L'association des parcs nationaux et provinciaux du Canada

Edmonton Chapter
13715-101 Avenue
Edmonton, Alberta

A BRIEF CONCERNING THE ENVIRONMENTAL EFFECTS OF SULFUR EXTRACTION GAS PLANTS

Presented by: R. Walsh

Presented to: The Environment Conservation Authority

October 19, 1972

National and
Provincial Parks
Association of
Canada

L'association
des parcs nationaux
et provinciaux du
Canada

Edmonton Chapter
13715-101 Avenue
Edmonton, Alberta

On behalf of the Edmonton Chapter of the National and Provincial Parks Association of Canada I wish to make a few brief remarks regarding the environmental effects of sulfur extraction gas plants in Alberta. The reasons for our concern arise not only from the overall environmental damage which such plants are capable of causing, but more particularly from the effect they may have on one aspect of environmental resource use, recreation. This is not to say we do not recognize the problems these plants may give rise to regarding industrial and agricultural land uses, but we feel that others will have much to say on those aspects.

As pressures for more recreational space increase, additional lands will have to be made available to prevent overcrowding of existing national and provincial parks. Many potentially suitable sites in the foothills are near sulfur extraction plants. Emissions from such establishments could well preclude the use of some large areas for recreation because of their odour, even at levels which may be low enough not to cause physiological damage to plants or animals.

We applaud the new emission standards established by the Energy Resources Conservation Board as a step in the right direction, and would hope that in the near future such standards will be again revised. At least 99%, if not 99.9%, recovery of sulfur from all plants in Alberta should be attained, and we strongly urge that such standards be set with the least possible delay. It is our opinion that continuous monitoring of stack gases for sulfur containing compounds is highly desirable and should be made compulsory for all sour gas plants in Alberta.

We further suggest the establishment of a much more extensive off-site monitoring system capable of determining quantitatively the ground level concentrations of sulfur compounds under varying local topographical and meteorological conditions. Costs of such a program should be borne by plant operators. To complement this program, more attention should be given to the monitoring of possible pollutants

National and
Provincial Parks
Association of
Canada

L'association
des parcs nationaux
et provinciaux du
Canada

Edmonton Chapter
13715-101 Avenue
Edmonton, Alberta

from sour gas plants and related facilities reaching surface and subsurface water systems.

With the establishment and maintenance of such monitoring programs, it should be possible to assess whether emission control standards are adequate to maintain acceptable ground level concentrations. Such ground level concentrations, in our opinion, should be so low as to cause no short <u>or long term</u> degradation of the environment, even if this degradation may involve only the presence of an odour or taste.

We would dispute any suggestion that increased recovery standards not be set until such a monitoring program can be established for two reasons:

1. If current emissions had no ill effect, public hearings would not now be enquiring into this field as a result of complaints.
2. If errors are to occur, better they should be on the side of environmental safety.

Such programs as we have hereby asked to be initiated will be expensive. So be it. If present market prices for gas do not permit the industry to make the necessary investment in pollution control equipment and still retain an acceptable level of profit, the industry should still be required to install such equipment. We, the public, as gas consumers are prepared to pay the higher gas prices which must follow.

QUESTIONING BY THE AUTHORITY

DR. S.B. SMITH

You said right at the end that the question of the economics of the operation has been before us all the way through and there is no question about the fact that Alberta has very low rates to consumers. How strong is your association on the idea of paying for instance 60¢ instead of 45¢ a unit delivered at the house, or whatever it might be?

MR. R. WALSH

I feel that we will pay whatever price is required to introduce the required pollution control.

DR. S.B. SMITH

And you think your association supports that position?

MR. R. WALSH

I think so, yes.

MR. W.A. FLOOK

You are advocating increased monitoring in essence?

MR. R. WALSH

Yes.

MR. W.A. FLOOK

Have you any idea at all of what size of monitoring program is involved, how many units scattered over what area?

MR. R. WALSH

I understand from Dr. Klemm's report, and other literature I've seen that this would be rather expensive, that the cost would be rather quite high.

MR. W.A. FLOOK

Do you visualize, for instance, a series of concentric circles which has monitors going out for twenty-five miles out around the gas plant?

MR. R. WALSH

I really have no conception of the actual physical set-up of the system that would be required, but I imagine I would quite likely emphasize more the areas downwind of the prevailing winds because this is likely where most of the emissions would end up. I really don't know as to the distance downwind or as to the number of monitoring stations required or in fact to their actual makeup. No one seems to know in the report, they mention only that there is a large shortage of data. I think everyone here today said that. And the only way to get that data is to establish a monitoring program, which, if after you have establish it proves not to be large enough, then it must be expanded yet again.

MR. W.A. FLOOK

Irrespective of cost in every case?

MR. R. WALSH

Right.

BRIEF

concerning

ENVIRONMENTAL EFFECTS OF THE OPERATION

OF SULPHUR EXTRACTION GAS PLANTS.

Submitted to

THE ENVIRONMENT CONSERVATION AUTHORITY

BY

Mieczyslawa Gawlak

9744 - 65 Avenue, Edmonton

September 19, 1972.

EFFECTS OF SULPHUR DIOXIDE ON VEGETATION
AND
OTHER ENVIRONMENTAL CONSIDERATIONS

SUMMARY

Damage to vegetation caused by atmospheric emissions of sulphur dioxide is briefly examined. The symptomology of exposure of vascular plants to sulphur dioxide parallels the symptomology of climatic and phytopathologic damage. Examination of bryophyte populations is suggested to supply less controversial data. Study of distribution and growth of lychens and mosses provides a record of air quality by biological indicators. Provincial government is urged to build an adequate system to monitor air quality in the Province. Acceptance and operation of airborne remote sensing instrumentation offered by federal government could provide a very effective means of achieving this. Additional benefit would be surveillance of the health of the vegetation.

Efficient recovery of sulphur dioxide must be required of gas processing industry. Time may be allowed the companies to evaluate new processes available for recovery of sulphur from the tail gases of the Claus recovery plants. To minimize the environmental damage due to sulphur dioxide while this evaluation is being carried out no further increase in production should be allowed. Present production level could be reduced to encourage expediency in research and plant installations. Production levels to be restored and/or increased when the processing plants have installed the high efficiency sulphur recovery equipment.

A call is made for public hearings on development of the Athabasca oil sands.

EFFECTS OF SULPHUR DIOXIDE EMISSIONS ON VEGETATION

The oldest sources of sulphur dioxide emissions in Canada are located in Trail, B.C., and in Sudbury, Ontario. The Consolidated Mining and Smelting Co. in Trail has been causing environmental damage in B.C. and the state of Washington since 1930's (1). The company has yet to make its operations environmentally acceptable. International Nickel Company of Canada Ltd. and Falconbridge Nickel Mines Ltd. operate 3 nickel smelters and 2 iron ore recovery plants in Sudbury. Their combined emissions of sulphur dioxide have damaged the surrounding vegetation continuously since 1940's (2), until presently 700 square miles are severely affected, and total of 1,600 square miles show some vegetation injury (8).

Damage to natural and cultivated vegetation in the Sudbury area is the most extensively studied Canadian example of plant injury due to sulphur dioxide. The studies of the area formed an integral part of the basis on which the Ontario sulphur emission standards have been formulated (3-7).

Severe damage to vegetation occurs through short-time exposure to high concentrations of sulphur dioxide, or to **repeated** exposures at sub-lethal concentrations. Toxicity of sulphur dioxide at any concentration depends on many variables. These are:

1. Duration of exposure;
2. Atmospheric conditions of
    a) humidity,
    b) temperature,
    c) intensity of light;
3. Soil moisture;
4. Species of plant concerned;
5. Rate of growth at the time of fumigation;
6. State of maturation of the respiring parts.

In general, the conditions which promote fast growth, i.e. humidity, higher temperature, intense sunlight, etc., are also the conditions which

create dangerous environment for the plant if sulphur dioxide is present. Plants are most susceptible to injury during the period of active growth.

One can argue here that higher emissions of sulphur dioxide during winter months when the activity of the industry is greatest coincide very happily with the period of dormancy for the plants. It must be remembered however, that the ability of the atmosphere to clean itself through photo-oxidation of sulphur dioxide to sulphur trioxide and through removal of the toxic agent by precipitation is also the lowest during winter months. The protective effects of lower respiration rates may well be outweighed by the build-up of sulphur dioxide in the atmosphere. That this, in fact, is happening is indicated by the analysis of field data on sulphur dioxide collected at sixteen plants in Alberta. The analysis shows Dec. - Jan. concentrations of SO_2 3 times as high as June-July figures (9).

The symptoms of sulphur dioxide injury are similar to symptoms of damage resulting from frost and wind action, drought, insects and disease caused by bacteria, fungus, or virus (8). It is therefore a simple and easy matter for the operators of sulphur emission sources to disclaim all responsibility for damage and blame the injury on other causes.

In order to ascertain the true cause of the injury biological indicators more specific than trees can be used to detect exposure to toxic action of sulphur dioxide. Mosses and lychens are very sensitive to sulphur dioxide. Extensive studies have been carried out on the effects of sulphur dioxide on their growth and distribtuion (10). Both have been correlated to concentrations of sulphur dioxide in the surrounding air. Epiphytic vegetation maps have been constructed as indicators of the severity of air pollution (10 b, c, d). Therefore, surveys by biological indicators should be included in the surveillance program of the Province in addition to surveys by chemical methods. Unlike chemical surveys which apply only to the moment of measurement, surveys by biological indicators are able to yield a record of air quality over a period of time.

Mosses, lychens, weeds (11), planted crops and trees can be used in evaluation of air quality. Tables exist (1, 4, 5, 11-19) listing relative sensitivity to sulphur dioxide of some natural and cultivated plant species. Planting of indicator species in strategic locations may be used as another means of evaluating the quality of air and its safety to the vegetative, and dependant on it the animal, assets of the Province.

The present monitoring service of Energy Resources Conservation Board is woefully inadequate to keep check on the areas subjected to sulphur dioxide emissions. The detection system depends on analytical data submitted by the operator and on complaints from public. Since majority of sulphur emissions are over scarcely populated areas and since neither plants nor animals can write or place a phone call, harmful emissions may remain undetected until excessive damage is done. Even if sufficient trained personnel and technical equipment were available the effective monitoring of inaccessible forested areas would still be impossible. The only reasonable solution to the problem is the use of remote scanning with infrared radiation detectors. I urge the provincial government to resort to these latest technological advances in detection of air pollutants in the atmosphere. The reluctance of the provincial government to accept the federal offer of airborne remote sensing equipment is difficult to understand and to justify. One plane equipped for such sensing can provide instantaneous information on large areas covered in flight. Additional analysis of aerial photographs can give an early warning of forest or crop damage, whether due to natural causes, or to air pollution. The personnel of the Department of the Environment and the Department of Lands and Forests can then take remedial action before the damage reaches disaster proportions.

OTHER ENVIRONMENTAL CONSIDERATIONS

The gas processing industry feels that present controls and operation procedures are adequate. Assuming 95% overall efficiency on sulphur recovery,

the industry vented into the air a total of 450,000 long tons of sulphur dioxide in 1971. This is 1,233 long tons per day. This figure does not include sulphur dioxide vented by the 25 gas processing plants which are not required to recover sulphur.

One third of total processing of gas takes place in the Whitecourt area. This area receives now approximately 400 long tons of sulphur dioxide every day. At full production capacity the figure will be 800 long tons per day. This will be approximately 1/8 of the amount now vented over Sudbury (8) which is responsible for 1,600 square miles of damaged vegetation. This comparison has to be tempered by the fact that damage in Sudbury area accumulated over 30 years of operation. Nevertheless, with the certainty of processing of gas being with us for the next 15-20 years, sulphur dioxide emissions must be taken seriously and standards of operation set so as to prevent environmental damage.

Hitherto, the response of industry to demands of lower levels of gaseous waste was to build higher and higher stacks. Thus, International Nickel has 6 stacks ranging from 350-637 feet. Falconbridge Nickel dispenses their effluent through 3 stacks 304 - 450 feet high. The Allied Chemical Canada has recently built a sulphur recovery plant in Sudbury area with a waste stack 1,250 feet high. Assumption here, of course, is that dilution is the solution to pollution. Such attitude is evasive and irresponsible. For even if the concentration of sulphur dioxide at the ground level is reduced to the point of being harmless to vegetation, which is not the case, there are other environmental factors which have to be considered.

Enormous tonnages of sulphur are being dispersed over the land area surrounding the gas processing plants. Sulphur accumulates in soil, air and lake waters. When annual growth of vegetation is insufficient to use up the sulphur deposited in the soil, the pH of the soil changes. The increased acidity reduces the productivity of soil and reduces the number of plant species able to grow on it.

High emissions at Sudbury raised sulphate concentrations in waters of surrounding lakes and reduced the yield of aquatic flora in them (20-22).

Ammonium sulphate has been found to be the main constituent of particulate matter building up in the stratosphere (23). The effect of this build-up is not certain yet. Scientific speculation is that presence of particulates in the stratosphere may drastically reduce its content of ozone, and hence, its protective shielding of earth from harmful solar radiation.

Responsible attitude to the management of our resources is to operate in the present in such a way as not to impair the assets of the future, or indeed, event the Life itself.

The above environmental considerations speak against perpetuating the undesirable practice of venting sulphur dioxide into the atmosphere. Sulphur emissions must be eliminated at source not diluted in the environment.

Attempts to increase sulphur recovery by adding third and subsequent catalytic converters to the Claus process result in high expenditure with diminishing returns. It seems reasonable to allow the industry time to evaluate the new methods of cleaning the Claus tail gases. Particular encouragement should be given to evaluation on plant scale of the method deveoped by Alberta Sulphur Research Ltd. (24). This method gave 99.9% recovery in the laboratory. Carbonyl sulphide and carbon disulphide, two minor but very poisonous constituents of the tail gas, are destroyed in the process. This advantage is not obtained in Sulfreen or I.F.P. procedures, both of which are being tested on production sites. From the environmental point of view the ASR process is superior to both the Sulfreen and the I.F.P. methods of tail gas clean-up. Every encouragement should be given to its incorporation into the sulphur recovery plant.

The environmental impairment must be kept at a minimum while the industry is evaluating and testing these new processes. Therefore, in addition to strict enforcement of the existing standards, the production of natural gas should be frozen at, or preferably reduced from the current production level. This, in addition to protecting the environment, will give industry a reason for speeding up the research on, and the installation of, the new sulphur removal equipment. Only then an increase in production

of natural gas could be allowed.

I, for one, fail to see why we in Alberta must suffer personal ill health and losses, environmental degradation, and bespoilage of our agricultural lands, forests and wildlife to supply citizens of United States with clean and cheap fuel.

CALL FOR PUBLIC HEARINGS ON THE PROGRAM OF DEVELOPMENT OF ATHABASCA OIL SANDS.

Development of Athabasca Oil Sands will increasingly intensify in the near future as the sources of conventional crude will be drying up. Oil sands deposits in Alberta underlie an area of 8 million acres and contain a reserve of 746 billion barrels of oil. 415 billion of these are considered recoverable (25).

The Athabasca oil sands deposit - which is bisected by Athabasca River - constitutes 89% of total provincial reserve of oil sands. 19% of the Athabasca deposit is under less than 250 ft. of overburden. The low overburden area runs parallel to Athabasca river. Assuming uniform distribution of oil in the oil sands - which is only a crude assumption - the shallow overburden area covers 1,045,000 acres. In all probability this will be the section of the oil sands to be exploited first by the method of strip mining.

Environmental problems in development of oil sands will pertain to pollution of water, reclamation of soil, and emissions of sulphur dioxide.

Sulphur content of Athabasca oil sands is 5% (26). Assuming 70% yield of synthetic crude,each 50,000 barrel/day production unit will utilize 71,000 bbls/day of unrefined crude. This is equivalent to approximately 13,000 tons of crude containing 650 tons of sulphur. At 95% recovery, 32.5 tons of sulphur per day, or 65 tons of sulphur dioxide will be vented for every 50,000 bbls of production.

Great Canadian Oil Sands Company is presently venting at least this amount into the atmosphere. This figure will be quadrupled to 260

tons of sulphur dioxide per day, or 95,000 tons per year, when Syncrude starts its 150,000 bbls/day production in 1975.

Emission of sulphur dioxide is only one reason for concern. Reclamation of land, disposal of process waters, protection of lakes and the river, will pose equally serious, or even more serious problems.

I wish to take this opportunity to bring the grave environmental dangers associated with the development of the Athabasca oil sands to the attention of the Environment Conservation Authority. The gigantic scale of possible environmental damage warrants full disclosure of plans for development of the oil sands and most severe public scrutiny of them. Program of development, if it exists, must not be implemented without public hearings on the subject.

REFERENCES

1. Katz, M. Effect of sulphur dioxide on vegetation. National Research Council. No. 815, Ottawa, 1939.
2. Katz, M. Sulphur dioxide in atmosphere and its relation to plant life. Ind. Eng. Chem. 41,2450-2465, November 1949.
3. Linzon, S.N. The influence of smelter fumes on the growth of white pine in the Sudbury region. Joint publication Ont. Dpt. Lands and Forests, Ont. Dpt. of Mines. Toronto, Ontario, 1958.
4. Dreisinger, B.R. Sulphur dioxide levels and the effects of the gas on vegetation near Sudbury, Ontario. Presented at the 58-th Annual Meeting of the Air Pollution Control Association, Toronto, Ontario, 1955.
5. Linzon, S.N. Sulphur dioxide injury to trees in the vicinity of petroleum refineries. The Forestry Chronicle, 41, 245-250, June 1965.
6. Linzon, S.N. Damage to eastern white pine by sulphur dioxide, semi-mature-tissue needle blight, and ozone. Air Pollution Control Association, 16, 140-144, March 1966.
7. Dreisinger, B.R. Monitoring sulphur dioxide and correlating its effects on crops and forests in the Sudbury area. Presented at Impact of Air Pollution on Vegetation Conference, Park Plaza Hotel, Toronto, April 7-9, 1970.
8. Linzon, S.N. Effects of sulphur dioxide on vegetation. Preprints. 1971 Annual Meeting of Air Pollution Control Association Pacific Northwest International Section, Nov. 21-23, Calgary, Alberta. No. 71-AP-25.
9. Beauchemin, P.A., Nader, W., Earl, G. Ground level concentrations of sulphur recovery plants in Alberta vs. predicted. Preprints. Ibid., no. 71-AP-38.
10. Syratt, W.J., Wanstall, P.J. The effect of sulphur dioxide on epiphytic bryophytes. Air pollution. Preceedings of the 1st European Congress on the Influence of Air Pollution on Plants and Animals. Wageningen, April 22 - 27, 1968, pp 79-85.

b) Barkman, J.J. The infuence of air pollution on bryophytes. Ibid. pp 197-209.

c) LeBlanc, F. Epiphytes and air pollution. Ibid., pp 211-221.

d) Gilbert, O.L. The effect of SO_2 on lychens and bryophytes around Newcastle upon Tyne. Ibid,. pp. 223-235.

e) van Raay, A. Use of indicator plants to estimate air pollution by SO_2 and HF. Ibid, pp 319-328.

11. Benedict, H.M., Breen, W.H. The use of weeds as a means of evaluating vegetation damage caused by air pollution. Proceedings of the third National Air Pollution Symposium, Pasadena, Calif., 1955.

12. O'Gara, P.J. Sulphur dioxide and fume problem and their solutions. Ind. Eng. Chem. 14,744,1922.

13. Thomas, M.D., Hendricks, R.H. Effect of air pollution on plants. In: Air Pollution Handbook, McGrow-Hill Book Co., New York 1956.

14. Zahn, R. Effects of sulphur dioxide on vegetation-results of experimental exposure to gas. Staub 23, 343-352, 1961.

15. Zimmerman, P.W., Hitchcock, A.E. Susceptibility of plants to hydrofluoric acid and sulphur dioxide gases. Contrib. Boyce Thompson Inst. 18,263-270,1956.

16. Buck, M. Experiments on the effects of air pollution. Ref. 10, pp. 53-75.

17. See ref. 10 e).

18. Wentzel, K.F. Resistance of plants to air pollution (ger.), ref. 10, pp 357-370.

19. Pollanschuetz, J. The susceptibility of various tree species to SO_2, HF and magnetic dust pollutions. (ger.) Ref. 10, pp 371-377.

20. Gorham, E., Gordon, A.G. Some effects of smelter pollution northeast of Falconbridge, Ontario. Can. J. Bot., 38, 307-12, 1960.

21. Idem. The influence of smelter fumes upon the chemical composition of lake waters near Sudbury, Ontario, and upon the surrounding vegetation. Ibid., pp. 477-87.

22. Idem. Some effects of smelter pollution upon aquatic vegetation near Sudbury, Ontario. Can. J. Bot. 41, 371-78,1963.

23. Inadvertent Climate Modification. Report of the study of Man's impact on climate (SMIC). Cambridge, Mass. 1971.

24. ASR sulphoxide process. Chemistry in Canada 24(8), 7, Sept. 1972.

25. Pow, J.R., Fairbanks, G.H., Zamora, W.J. Descriptions and reserve estimates of the oil sands of Alberta. In: Athabasca Oil Sands. Ed. M.A. Carrigy, Research Council of Alberta, 1963, pp 1-14.

26. Brese, W.G. Outlook for the Alberta Sulphur Industry. Ibid., pp 231-238.

QUESTIONING BY THE AUTHORITY

DR. S.B. SMITH

You suggested that it would not be unreasonable to allow the industry some time to evaluate new techniques which have been mentioned publicly in the last short while. I wonder if you care to add a little bit to how long do you think is reasonable?

MISS M. GAWLAK

That is a question that I cannot answer; but two of these processes, the sulphrene process and the IFP process are already being tested on the gas production sites in Alberta. The first one, the sulphrene is on Rain River site, the other is on the Long Pine Creek site. The process has been proposed, the laboratory experiments have been done, the process has been incorporated into the production cells and now the evaluation of it is going on, so I don't think it will be long before industry has the answers. These two particular processes have not been tested on any larger scale than just laboratory, so this of course will be what is needed to test them out.

MR. W.A. FLOOK

You indicate that because of the reduced ability of the air to take care of sulphur dioxide emissions in winter, that the background content of sulphur dioxide is three time as high in winter as it is in summer.

MISS M. GAWLAK

The data which have been taken around sixteen plants indicate that the concentration of sulphur dioxide around the plant site is three times the corresponding points between summer and winter.

MR. W.A. FLOOK

Does it, in fact, return to its original levels every summer or is it building up from year to year?

MISS M. GAWLAK

No, the level actually varies. It depends on climatic and wind conditions. I don't think that it is comparable with exactly the same moment last year.

MR. W.A. FLOOK

Have you had any data to indicate that the background level is indeed building up at all?

MISS M. GAWLAK

It is building up in winter.

MR. W.A. FLOOK

I mean at any level, at any time overall?

MISS M. GAWLAK

No, because the atmosphere actually has sulphur dioxide. It does not build in the atmosphere. The life style of sulphur dioxide molecules is relatively short. It unites with moisture and forms sulphuric acid. This, in part, reacts with other gaseous compounds or particles that are suspended in the air to produce ammonium sulphate, the major particulate into which sulphur dioxide is changed. A lot of sulphur dioxide is being pushed out by precipitation.

Someone was commenting the sulphur emission levels acknowledge that the environment can take care of sulphur because the sulphur dioxide doesn't build in the atmosphere. Now, it does not build in the atmosphere because the precipitation and the other conditions remove it from the atmosphere. Whether it's built up in the soil or in the environment, or if it is generally harmless or not, I don't think that that's the right inference to make or not.

MR. W.A. FLOOK

You are assuming that in spite of the addition and the removal, the background level as resident in the air at any time is remaining constant.

MISS M. GAWLAK

I don't know if it's constant or not; but whether it decreases, I suppose that it

probably depends on conditions. It's a very local concentration, it's a very local factor. It probably depends on the amount emitted from the plant, on the environmental conditions, and on the amount of precipitation that the area receives. It's very variable, and I don't know whether we can talk about constant levels or not.

ADDENDUM TO CANADIAN PETROLEUM ASSOCIATION BRIEF

Presented by E.E. Cudby

Thanks, Mr. Chairman. My name is E.E. Cudby and I happen to be Chairman of the Environmental Conservation Committee of the Canadian Petroleum Association. Something has arisen this afternoon that prompts me to ask the Authority if we could make a last statement before this hearing closes. Mr. Gainer had indicated that we had planned to make an epilogue to this particular hearing. We were originally proposing to present it this afternoon as part of the record, but it was agreed that because of the time element involved it would be as appropriate to address this to the Authority in a letter.

We would like to make one statement here which we think is very important. We wish to reitorate, Mr. Chairman, that industry is willing to join with any governmental agency in discussing any proposed establishment of guidelines or standards. This we assume on the basis of the past reasonably good industry government relations. Certainly this has been true in the past. We have worked with the Government in many ways in the establishment of regulations and have lived with these to date. These relations have been such that no new guidelines or changes in standards would be established unilaterally without any further discussion. This then precludes any government or regulatory agency imposing imminent or sudden demands on the industry via new legislation without its prior knowledge or without being given sufficient time to defend such status as may be deemed appropriate to this situation by the industry based on good supportable, practical common sense and scientific evidence. That is the statement that would be included in the epilogue.

I would like to further add, if I may, that back in May when we first approached this particular problem as to whether the Canadian Petroleum Association should enter into it and make some objective statements, or even some analysis of the total problem; we had to go to the Canadian Petroleum Association Board of Directors and get from them an

amount of money. We indicated to them the basis of the need to do this for the industry because we had heard that the Energy Resources Conservation Board was generating some new guidelines for sulphur recovery efficiencies which were thought to be a necessary and desirable thing for the industry in the future. These particular sulphur recovery efficiencies then would be upgraded from what they had been in the past. The establishment of recovery efficiency had been in the past in the approvals and it would be upgraded at that time. This still has not become a fact. Also we were aware of the fact that the Department of the Environment was talking in terms of reducing the ambient air quality standard, in one particular area at least, from 0.3 parts per million down to 0.17 parts per million.

In view of these two things that would possibly transpire, we addressed ourselves to this question with the idea of making our presentation. We then got the approval of the Canadian Petroleum Association and we indicated to them that we would endeavour to hire as many consultants as we thought would be necessary to address themselves to the various aspects of this total problem. It was not our intention to dazzle the Authority at all. It was our intention to get the best expertise we possibly could on the subject to state their case. Then, having done this, we would make this presentation to the Authority with the idea, in view of all the statements that were made on both sides about the industry, the public and the government; that if the government did not then see fit to change the ambient air quality standards, or set up these particular recovery efficiency guidelines, that's the way it would probably be.

Mr. Chairman, I am aware now that not only were these statements that were made previously by Mr. Yurko, suggesting that these might come about (and this was particularly stated in public at a C.I.M.M.E. meeting in August), we thought there was still some time left because we were talking in terms of the sulphur recovery efficiency guidelines probably meeting the new ambient air quality standards somewhere probably next year - maybe at the end of next year. We thought possibly

that this particular hearing might have some bearing on the outcome of these things, but we understand right now that not only is the new ambient air quality standard in draft form, but we also understand that it is probably going to be promulgated before the end of this year, and will probably not be dealt with in the legislature. They may be dealt with at the ministerial level (they don't have to be apparently), and that they could come into law by a stroke of the pen by the Chief Minister of the Department of the Environment, and that all this will come about before the end of this year. This strikes us as rather odd that we have had this lengthy hearing and that if this is a 'fait accompli' I am wondering, sir, perhaps what this particular hearing is all about. If I remember correctly, this particular brochure that was sent around to the public and to industry, that within that brochure it indicated that we were to address ourselves to the legislation among other things with the idea that maybe some new legislation would take place at some future date, but, if this is already a 'fait accompli' I am just wondering just what our postion is at this time. Could I just stop there for one moment. This is my presentation insofar as the CPA is concerned.

I would like to make one further statement if I may as a private citizen. It seems to me that there is a possibility, if all these facts that I have just stated are true, that it makes a mockery of this particular hearing. There are hundreds of thousands of dollars being spent with the view that facts would be brought to light and that on these particular facts judgments would be made. If on the basis of these facts it was felt that the ambient air quality standards or any other regulations would have to be changed, again, so be it. We accept that fact. Everybody has a right to make their particular statements, but I would suggest that is this, the aforementioned statement, is a fact, it does kind of make a mockery of this hearing.

QUESTIONING BY THE AUTHORITY

DR. W.R. TROST

Well, I must say that we have done it in good faith and I think that anything that is projected for the future really can't be a fact.

MR. E.E. CUDBY

Are you, or any member of the Board, aware of this new legislation becoming a fait accompli before the end of this year?

DR. W.R. TROST

No.

MR. E.E. CUDBY

Thank you.

MR. B. WANNAMAKER

Perhaps the credibility of the Canadian Petroleum Association. In the Canadian Petroleum Association's conclusion which deals with the importance of their industry in Alberta and Canada as a whole I believe that that has very little to do with the environmental impact of the industry. It is more a fact a warning that you play the game our way or we'll take our ball and go home, and I think there is very little danger of that. I think with the need for sulphur and for gas presently that they'll stay. In the recommendation which deals with leaving the standards the way they are and dealing with ambient pressure at ground level, I think the foolishness of that statement was pointed out very well by Dr. Summers. I think it's unfortunate that C.P.A. will get a chance to mail a letter to your group after this Public Hearing and still have no response from the public.

Going on to Mr. McAllister's speech, about the importance of sulphur, the cost of applying sulphur I think it would be unfortunate that it should have any bearing on your belief of how much sulphur dioxide should be allowed to come out of a plant; because it only costs a dollar per acre to apply it to the ground. You must consider that steel posts for example cost $1.45 a piece, but they don't last nearly as long in a plant area.

In Mr. Walsh's speech Mr. Flook again brought up the idea of economics. This is something that is also used in Sarnia plant especially, one or two of which said that putting in any pollution devices would force them to close down their plant. I think you perhaps have the best chance you will ever have in Alberta, that if you get the plant to install to these devices now, set up the recommendations now, there will not be any fewer plants in the future. Research into better equipment will be better and cheaper equipment will not come until after the company feels it is necessary. If they are put in now, money will be allocated for research and perhaps they will find a cheaper way of doing it. If you don't do it now they won't spend as much money on cheaper ways of getting the sulphur out. Next time this comes up it may be there will be twice as many plants and they'll say again that we just can't afford it.

MISS M. GAWLAK

I would like the Provincial standards to be set only by Provincial bodies. I don't think that it's desirable to have any input into setting of the standards by the industry itself because obviously they tend not to be objective. They've got a great corporate interest to protect which do not coincide with the interests of the public generally.

MR. J.G. GAINER

We have done impact studies in our industry for a tremendous cost. We have had them then done again for us by Federal Government agencies. The first step that Canada has taken subsequent to Stockholm is an action plant, a step from the U.N. action plan. After a day's discussion, the first attack for Canada was an impact study. In the learned group, however, no one could come down on impact in terms of whom. I mention this because, partly Miss Bonnett's speech, and partly the one by Mr. Geddes. The Federal Government is taking absolutely the longest range of view. They are talking of impact, they're talking very fundamentally how far back we go and to what end on an impact study so that nothing is left out. If is conceivable that we don't have time to wait for this. We may need something as an interim step. It should be Canada's overall role, as an outcome from Stockholm, that impact has been given this priority.

SUPPLEMENTARY SUBMISSIONS TO THE AUTHORITY

OCTOBER, 1972

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

PUBLIC HEARINGS

ENVIRONMENTAL EFFECTS OF THE
OPERATION OF SULPHUR EXTRACTION
GAS PLANTS IN ALBERTA

Pincher Creek, Alberta
October 2, 1972

Submitted by: Gordon Herd (representing)
Willow Drive Community Assoc.

Please consider this a valid complaint regarding sulphur plant pollution (Saratoga Processing Co.) in Coleman as it affects the people in the Willow Drive community.

This brief concerns me personally as I am directly affected by it, as my home is in direct line with the plant about one mile east. As I returned home one evening this spring I was getting out of my vehicle as I noticed a peculiar odor in my yard. I became nauseated and had a dizzy feeling. One dog was passed out and lying on its side and another was staggered. On going to my trailer, Mrs. Herd came running from the trailer complaining of a headache and saying that our cats were dying. I notified Charles Drain, our M.L.A., and told him of the incident. He sent the Environment Conservation Authority to investigate the matter. The personnel from the government arrived one week later when the air had cleared up some, and the results were negative. My lot, about four acres large, had about nine trees killed, and neighbors have lost approximately two hundred trees.

While hunting two or three miles south east of the plant, fumes are so bad one would think a valve was open. Others have complained of the same kind of condition.

On a separate sheet there are twenty-six names, a petition signed that all are complaining of sulphur pollution of some sort.

In conclusion, I would like to have an investigation into this matter as it affects the people of Coleman and mainly of Willow Drive.

Willow Drive Association

Bill Trotz.
Gordon Herd
K. R. Krish
Henry A France
John Rosner
Muriel Rosner
Mrs Marie Krish
H Pownall
A Thompson
Henry Mademann
Jacqueline Mademann
Alma Krish.
Walter L. Krish
Isabel Bayer.
Barbara Bayer.
mike Gyurniza
Shirley Gyurniza
David Dowsak
Willy [illegible]
D. M. Bennick

S. Hoekhager
Mary Miller
Archie Miller
M Juhlin
Bob Franz
Marie Franz

Typed copy of letter received from: D.V. Chapman
P.O. Box 264
Cochrane, Alberta

October 6, 1972.

Gentlemen,

Our land completely surrounds the Fina Plant on 1 A Highway. We did not receive a notice of your hearing, but heard of it through our neighbor, Mr. Curt Wheatley.

Our land has been affected by this plant. The odor at times is very bad, to the extent that the foul air comes into our home. When the gases are blown out and the black smoke circles the air, the pollution is terrific. We have had to contact the plant many times to clean up the area: papers, tin, etc. blow onto our land. In the last six years we have had at least three grass fires. The plant itself is quite an eyesore from the highway, and could be beautified with trees. At times you cannot even walk on the land directly east of the plant because of the foul air. You have to cover your mouth. From a sale point of view, this land and the land west of the plant has been terrifically affected. We have lost trees because of the sulphur in the air. We contacted the Pollution Control Board at Turner Valley, and we know they contacted the plant. For a while, about two months, conditions were a little better. Within the last month the emission of flames has become stronger, the black smoke more common, the odor very foul, and the plant more of an eyesore.

We had contact with the Land Office of the Fina Plant and told them these facts, about September 26, 1972.

Respectfully submitted,
Douglas Victor Chapman

Land owned by Douglas Victor Chapman:

Pt. N.W. 1/4 Sec. 15 - Twp. 26 - Rge. 5 - W 5th Mer.
Pt. S.W. 1/4 Sec. 15 - Twp. 26 - Rge. 5 - W 5th Mer.
Pt. N.E. 1/4 Sec. 16 - Twp. 26 - Rge. 5 - W 5th Mer.
Pt. S.E. 1/4 Sec. 16 - Twp. 26 - Rge. 5 - W 5th Mer.
Pt. N.E. 1/4 Sec. 17 - Twp. 26 - Rge. 5 - W 5th Mer.
Pt. S.E. 1/4 Sec. 17 - Twp. 26 - Rge. 5 - W 5th Mer.
S.E. 1/4 Sec. 22 - Twp. 26 - Rge. 5 - W 5th Mer.

Douglas Victor Chapman
P.O. Box 264
Cochrane, Alberta

Alberta Women's Institute

August 17, 1972.

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107th Street
Edmonton, Alberta.

Dear Sirs;

The members of the Alberta Women's Institutes are aware of the concern of Albertans in some areas with respect to sulphur extraction gas plants and related emissions.

Although this organization has no definite documentation regarding the degree of injuries to health of human and animal life, the Alberta Women's Institutes respectfully request the Departments of Environment to conduct such legislation and regulations to insure the safety of human and animal life and to protect the environment.

Yours truly,

C. McMillan

Mrs. George McMillan
Secretary Treasurer
Alberta Women's Institutes.

cm

Typed copy of letter received from: Mrs. S. C. Wheatley,

Mrs. S. C. Wheatley,
Box 427,
Cochrane, Alberta.

October 14, 1972.

Environment Conservation Authority.

Dear Sirs:

In answer to your letter of September 8, 1972, I am submitting the following information.

We are located directly east of the Fina Gas Scrub Plant, eight miles west of Cochrane on No. 1A highway and the Gas Plant certainly does affect us. At times the odor is so bad that I cannot work outside in my garden and often have to close the windows of the house to try and keep the odor out. I get severe headaches and nausea at times from the odor and acid released from the plant. Our evergreens in the garden are affected and in the winter months when they are not continuously hosed down they turn brown and the needles fall.

Quite often late at night the plant burns off waste and the black smoke rolls out over the area.

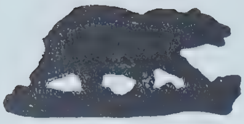
Very often there is so much acid in the air a person can taste it and it burns eyes, nose and throat, and causes sinus problems.

I know the amount of waste released in the air is detrimental to health and should not be allowed.

I sincerely hope more stringent regulations are brought into effect and enforced.

Yours truly,

Violet Wheatley



Mr. & Mrs. Casey Jones

Typed copy of a letter received from: Mr. and Mrs. Casey Jones,
Whitecourt, Alberta.

P. O. Box 835,
Whitecourt, Alberta
September 11, 1972

Environment Conservation Authority,
9912 - 107 Street,
Edmonton, Alberta

Dear Sir;

For the upcoming sulphur pollution hearing on October 11, in Whitecourt, please consider this letter as a vote for additional controls on the amount of sulphur, and smoke emissions from the gas plants in the Whitecourt, Fox Creek Area. Controls, that are effective to prevent additional wastes being emitted during opportune times, such as holiday weekends, during overcast, or late at night.

During my travels, by these plant sites I have found it rather odd to observe additional pillars of smoke at night. Also I note that many low lying areas in the Fox Creek, Whitecourt Berland River Country, contain atmospheres with a "nose burning" sensation. Surely, this type of air condition must be harmful to people and wildlife.

My position in Whitecourt is that of an oilfield supply sales engineer, well known to many of the management staff at these gas plants therefore, I cannot appear publicly at the hearing, without being concerned with my job position in the petroleum industry. I feel that this situation would be similar with many Albertans involved directly or indirectly, with the oil and gas industry along the foothills.

I do look forward to when the petroleum industry can achieve good production levels, without any discomfort to people and wildlife. I do believe the Environment Conservation Authority can help achieve this goal.

Yours truly,

F. N. Jones

Letter received from: Mr. J. A. MacLeod

39 Slocan Rd. SW
Calgary 13, Alta.
Oct. 17/72

Environment Conservation Authority
9912 - 107 St.,
Edmonton, Alta.

Dear Sirs,

I submit this to the hearings on the sulphur extraction plants as an owner of property within a mile of such a plant, namely the new Imperial Oil Quirk Creek plant, about 30 miles southwest of Calgary. My land description is $S\frac{1}{2}$ - 8 - 21 - 4 - W5.

About seven years ago my wife and I invested our savings in a piece of wooded foothills property, expecting that by now we would have built a home there, would have the beginnings of a small cattle herd and would be on our way to early retirement. We have had to pospone those plans. Gas was discovered under us and a sulphur plant built nearby. One can learn to live with the noise of such a plant, even though it is offensive, but not with a gas that has such a harsh effect on our respiratory systems. On our highest elevation, which is at least as high as the top of Imperial's stack, when we are down wind the effects are so bad we have to stay out of the area. On calmer days it settles in the lower parts. Imperial Oil, of course, has disclaimed any connection with such gases. When we asked them to set up air monitoring devices on our property -- for their use, not ours -- they declined. We then attempted to sell but found buyers uninterested because of proximity to the plant unless we sold at a loss. Certified appraisers (H.S. Kent, A.A.C.I., Calgary) advised that the presence of the gas plant had cut the value of our property approximately in half.

While this is a great disappointment for us I believe our problem is small compared with that of the people who <u>must live</u> near these plants and raise their children and livestock in such an atmosphere. It seems unbelieveable that these rural residents should have to bear the brunt of health effects and depreciation of property and quality of life.

The companies have made reference to the cost of increasing the efficiency of the sulphur extraction process. Surely such costs cannot be taken seriously when compared with public health and the rights of the individual. When the companies state (probably rightly) that they operate within air quality regulations on stack emissions they are merely ducking behind existing legislation to avoid responsibility and further expense. It's obvious they will not act on their own. Only legislation will do it; legislation based on facts such as the following:

1) We know sulphur dioxide is an unnatural, poisonous gas.

2) We know what it does to metal and to paint, even in very small amounts.

3) We know what it will do to plant and animal life in certain concentrations and that under certain weather conditions it occurs in such concentrations near sulphur extraction plants.

4) We know that if other living things are so affected, then the effect on human health has to be detrimental also.

5) The industry has known for several years of at least two processes whereby 99½% and possibly 100% of the sulphur can be extracted.

6) It has been suggested within the industry -- quietly -- that at least part of the stack effluent could be put into solution and injected into the ground, possibly right back into the natural gas formations.

7) Any establishment that makes a constant noise that can be heard over a mile away is having a serious effect on the aesthetics of the area and on the quality of life of nearby residents from the standpoint of sound alone.

The petroleum industry has been justifiably proud of its technological advancements. Unfortunately they have been directed almost entirely toward profits. It will cost money but I don't think it is an exaggeration to say there can be no doubt that it can turn such technical ability toward the above and do away with the sulphur dioxide problem and reduce noise levels. The industry has the know-how.

If I seem a bit blunt in closing I apologize. But I suggest, respectfully, that such a serious subject needs straight talk. For many years an inept administration in Alberta allowed, more than any other province, the petroleum industry to run roughshod over the rights of these rural residents. Now that we finally have a provincial Cabinet with some savoir-faire and intestinal fortitude I believe the time has come to do right by these people.

My motives, by the way, are not entirely selfish. My prejudice on behalf of the people on the land arises from years of association with them through my work as an agriculture and resources commentator in radio.

Yours sincerely

J.A. MacLeod

A BRIEF SUBMITTED TO THE ENVIRONMENT CONSERVATION

AUTHORITY HEARINGS ON THE ENVIRONMENTAL EFFECTS OF

SULPHUR EXTRACTION GAS PLANTS.

BY THE

WIGHTON FAMILY.

Carla Wighton

Pat Wighton

Dennis Wighton

4704 117th Street,
Edmonton, Alberta.

OCTOBER, 1 9 7 2.

We did not anticipate particiaption in these hearings due to the complexity of the problem and the level of knowledge within our family concerning Sulphur Extraction Gas Plants. However, the availability of Dr. Klemm's report at this late date has prompted us to take some action.

We are concerned about the delay in the publication of Dr. Klemm's report and also the screening and what appears deletions made by our Democratic dictatorial administration in the Department of the Environment.

We are also concerned at the way in which one individual with a highly specialized academic background was expected on a contractual basis to conduct and publish an interdisciplinary report which was impossible in so short a time.

We place no blame on Dr. Klemm for his efforts but only praise for a job well done under extremely difficult, if not impossible, circumstances. The responsibility lies soley with Mr. Yurko's administration for not allocating greater time, funds and interdisciplinary experts to the task.

The report is thus incomplete in the areas of the social and biological costs associated with resource development; local effects as they relate to well documented cases of mortality and morbidity in the Pincher Creek area; economic cost benefit analysis; capital stocks; ownership and employment; resource stocks, rates of consumption and depletion: and a tentative recommendation list so that stimulation of the public interest can be achieved.

In evaluating what knowledge we have available we state that the public is required to prove guilt in the case of damage by Sulphur Gas operations. This we feel is wrong when considering the present government's policy yet to be enacted, called, "The Polluter must pay", and when one considers the might and financial enormity of the gas companies which the individual would have to face.

The way in which the Department of the Environment has acted in the Pincher Creek caseis difficult to understand, perhaps it is because the problem is of an interdisciplinary nature and the various government boards and departments are unable to function together to investigate this case properly.

(Another fine example would be the City of Edmonton's Rosedale Generating Plant and its NOx and NO_2 emission permit, stack sampling and environmental effects).

We do not find in Dr. Klemm's report or other data available to the public, medical case histories of either Pincher Creek Ranchers and their livestock nor case records of sour gas extraction plant operators compared with a control population sample.

We are concerned as to the manner in which the monitoring of extracted material is required by the Energy Resources Conservation Board and the reasons behind this kind of after the fact situation which is allowed by government to approve emissions.

The Environment Conservation Authority undertook the task of exposing some of the problems associated with resource extraction in Alberta and asked the people of Alberta for their examination and comment. This example as with the past hearings on strip mining, plainly expose the interdisciplinary nature of our environmental problems and the struggle that society has in challenging the simple equation: Population + Consumption + Capital Investment, over Resource Exploitation = Pollution + Resource Depletion.

We hope, that by examining this equation and all its long-term consequences by workshops such as, Man and Resources, we shall be able to convince ourselves and governments that alternatives to our present system do exist.

Recommendations

1. Supporting E. C. A. reports for future hearings be published well in advance, (one month minimum) before the earliest hearing date in Alberta.
2. Supporting E. C. A. reports not be edited, censored or approved, by the Department of the Environment.
3. Supporting E. C. A. reports be undertaken with ample time to do a proper job and to be done by an interdisciplinary group of experts.
4. All resource extraction companies be required by law to prove there will be no environmental side effects before they commence their operations; sufficient funds be set aside by the industry to cover costs of public investigations.

5. Intensive interdisciplinary studies including medical case histories be undertaken immediately within all types gas extraction plants and related community areas. These intensive studies be funded by the Environmental Research Fund.
6. Jurisdictional complications between the Department of the Environment and the Energy Resources Conservation Board be immediately remedied, and consideration be given to include a more close relationship with the Industrial Health Department.
7. That complete environmental impact studies be undertaken for all resource extraction processes, in particular the forthcoming Athabasca Tar Sands.

A BRIEF PRESENTED TO THE ENVIRONMENT CONSERVATION AUTHORITY
ON THE "ENVIRONMENTAL EFFECTS OF THE OPERATION
OF SULPHUR EXTRACTION GAS PLANTS"

Submitted by:
Alberta Chapter of the Canadian Society
of Wildlife and Fisheries Biologists

We wish to make the following comments based on the Klemm Report submitted to the Environment Conservation Authority, September 1972.

1. We are appalled that a document resulting from public concern about human health problems and environmental quality should devote only 3 pages out of 116 to direct consideration of human health and only 3 additional pages concerning effects on livestock. Furthermore, apart from 5½ pages covering general comments on vegetation and soil, no information is presented on other components of the biotic community. For example, the wildlife resource and its inherent recreational value is not considered. This is alarming in that the extraction plants are primarily located adjacent to the eastern slopes of the Rockies where demands for recreation are ever increasing. We believe our concern is justified because the Klemm Report ignores one of the only well documented case histories of gas plant effluents causing extensive mortality of cutthroat and rainbow trout, mountain whitefish, and suckers (Radford, 1972).

2. The Klemm Report deals at length with physical-chemical techniques for monitoring both gaseous, solid, and liquid effluents. These procedures are of value to plant operation but their interpretation with regard to the living environment is virtually impossible because of such complicating factors as synergistic effects, short-term exposure to high concentration of effluents which may exceed biotic tolerances. Furthermore, as is evident in the report, these types of physical-chemical monitoring are so costly that all effluents cannot be continually monitored. However, the effects of effluents on the ecosystem can be adequately and inexpensively determined through the

use of biological indicators. For example, such plants as alfalfa, some cereal grains, and all varieties of squash are sensitive to sulfur dioxide (Klemm, 1972:97). Additionally, in the aquatic sphere many organisms are well known to be sensitive to pollutants and are thus excellent indicators of water quality. A local example cites the effectiveness of Ephemeroptera, Plecoptera, and Tricoptera in this regard (Radford, 1972).

3. We are concerned about both present and proposed procedures governing the operation of gas extraction plants. We note that all "process waste water" may not be treated before disposal to surface water (Klemm, 1972:57). Statements such as "wherever feasible hydrogen sulfide is to be combusted to sulfur dioxide," do not allay our concern because sulfur dioxide is not innoxious and, furthermore, the term feasible intimates that cost is the only consideration. In regard to monitoring water for consumption, the Klemm Report (p. 65) indicates that water samples are only analyzed if "their acceptability for consumption has been questioned."

Pages 67 to 69 of the Klemm Report deal with unsolved problems. We believe that most of these are of a critical nature. Included are such problems as designing leak-tight equipment; identification of odours; mud disposal; sulfur dust drifting; stack emission measurement; corrosion forcasting; spill contaminant; river crossings and oil spill clean-up in muskegs; lake shore and stream-bank protection; and "*wilderness areas compatibility*". This last problem should not be in the category of "unsolved problems" as we believe any consideration of the compatibility of the petroleum industry with wilderness areas is ludicrous.

LITERATURE CITED

Klemm, R. F. 1972. Environmental Effects of the Operation of Sulfur Extraction Gas Plants. Environment Conservation Authority, Edmonton, Alberta. 116 p.

Radford, D. S. 1972. The History of Pollution Investigations and Fish Kills on Drywood Creek, and Associated Waters, as Affected by Gas Processing Plant Operations. Fish and Wildlife Division, Department of Lands and Forests, Lethbridge, Alberta. 18 p.

PERCEIVED ENVIRONMENTAL EFFECTS OF SULFUR EXTRACTION GAS PLANTS IN SOUTHERN ALBERTA

A Brief Presented to the

ENVIRONMENT CONSERVATION AUTHORITY
PUBLIC HEARINGS ON THE ENVIRONMENTAL EFFECTS
OF SULFUR EXTRACTION GAS PLANTS

By

Dr. Don Gill
University of Alberta

October 1972

INTRODUCTION

Since 1970, the undersigned and several of his graduate students have been conducting investigations of alleged environmental pollution in the vicinity of sulfur extraction gas plants in Southern Alberta. A report of this activity may be seen in a brief submitted to the Alberta Department of the Environment in November, 1971 entitled "Environmental Pollution in the Drywood Creek Region of Southern Alberta", which was authored by M. Stick, P.A. Bonnett, and D. Gill. Copies of this brief are on file with the Environment Conservation Authority and the Alberta Department of the Environment. An additional account of this study is contained in the 1972 Summer Issue of the Alberta Conservationist (pages 8-10).

PURPOSE

The purpose of the present brief is to reiterate some of the material covered in the previous accounts and to add other relevant information.

HISTORICAL BACKGROUND

In the late 1940's, commercial quantities of natural gas were proven in Waterton-Twin Butte ranching area of the Municipal District of Pincher Creek. By 1957, the British American Oil Company (later Gulf Oil Ltd.) had established a plant to process gas and extract 50,000 gallons of propane and butane and 675 long tons of sulfur per day. Shell Canada established their plant in the far more productive western field. Operations commenced in 1962, producing 6,500 barrels of pentanes and 1,000 long tons of sulfur per day, with a design capacity of 8,000 barrels of pentanes and 1,500 long tons of sulfur per day.

AIR AND WATER POLLUTION AS PERCEIVED BY RANCHERS LIVING IN THE VICINITY OF GAS PLANTS

With the commencement of production, some forty ranching families in the vicinity began to complain of discomfort from gas fumes; several individuals experienced recurrent illnesses which they attributed to concentrations of noxious gases originating from the gas plants. Livestock production at this time was allegedly affected and there were reports of damage to property and machinery. Ranchers' complaints to Alberta Provincial Government authorities and to the companies were investigated and eventually dismissed as hysteria. In late 1966, incensed at what they considered to be unfair treatment at the hands of government and industry, some of the ranchers instituted legal proceedings to gain compensation for what they claimed was the unnatural way they had to operate land which had been in their families for up to three generations. After five years, this lawsuit was terminated by the action of the oil companies who purchased an easement to continue the release of gas over the property of those ranchers who agreed to this procedure.

Some twenty-five to thirty families who were not involved in this lawsuit remain uncompensated, however, and in their view the pollution problem continues.

The health problems alleged to have been experienced by ranchers since the establishment of the gas plants have never been adequately documented but include common ailments such as headache, insomnia, skin, throat and eye irritation, stomach cramps, lassitude, nausea, nosebleeds and diarrhea. Other less common ills have also been experienced, including loss of appetite, anaemia, loss of the sense of balance, no weight gain in children, loss of kidneys (one male in mid-thirties),

complete debilitation, temporary and permanent losses of vision, loss of speech, temporary paralysis, loss of normal movement (one male in mid-thirties), and severe allergy to domestic water supplies in the form of nausea and swelling.

Local doctors have been reported as saying that many of these symptoms are quite prevalent throughout southern Alberta and thus should not be attributed to effects of sulphur gas processing. This of course may be correct, but until an appropriate survey is conducted it is not reasonable to dismiss the complaints as purely psychosomatic, since the effects of gas plant operation upon the mental health of the local residents seems to have been quite detrimental. When people come to believe that they are being subjected to environmental contamination, and frequently experience symptoms of ill health, they should not be dismissed as hysterics. Whether or not the building of the two gas processing plants in the Drywood Creek valley has actually contaminated the environment is still to be fully determined, but there can be no doubt that the attitudes of many current and former residents have been dramatically changed toward this type of operation in the last fifteen years.

In addition to the perceived damage to their own health, residents also maintain that air pollution accelerates corrosion of paintwork on buildings and machinery. They believe that there is occasional damage to vegetation and many ranchers attribute loss of livestock to the inhalation of fumes discharged from the stack of the processing plant.

The high degree of concern shown by families in localities close to the processing plants has produced two kinds of behavioral response. Some have become so wearied of the perpetual health problems that they have left their land

and moved to the town of Pincher Creek or other locations and now travel back and forth to farm the land and tend their animals. Others have stayed and are still experiencing a variety of afflictions although some admit that things are improving because the industry has been cleaning up its operation in the last five years. There are still reports of cattle dying in mysterious circumstances and individuals suffering a variety of discomforts after drinking water from a well which in the past provided palatable drinking water.

When the question of the government's role in protecting the public from environmental contamination is raised, feelings among the affected ranchers run quite high. Over the last decade they have developed a hostility toward government officials who have tended to dismiss their complaints because the causes were not immediately obvious. From the evidence available in government files it seems that numerous public complaints have been investigated and generally shown to be trivial or erroneous. Regular monitoring of air and water quality in the vicinity of the gas processing plants was instituted but has been limited in the range of compounds checked. A general response by the government has been to conduct ad hoc studies over short periods of time which have discredited the ranchers' complaints and accusations. This has undoubtedly harmed the relationship of the two parties and explains the generally hostile attitudes prevalent in the ranching community toward the government. A widely held belief in the Drywood Creek area is that economic considerations have caused the government in the past to listen more closely to the claims of the gas industry (that no pollution problems are caused by their plants) than to listen to the pollution problems claimed by the ranchers.

THE DISADVANTAGED RANCHER

The typical rancher in southern Alberta is relatively unaware of his reciprocal relationships with his environment. He also is unlikely to be familiar with technical details of industrial processes. Furthermore, the ordinary person is without large financial resources or access to a variety of experts such as environmental consultants and lawyers. In sum he is not well equipped to undertake research over a long period of time or to collect and analyse information to prove that his health or property is being damaged. Nevertheless during the last decade in Alberta this is the demand which society has placed upon the individual who believes himself damaged by resource exploitation. The onus is on the lay public to prove that they have been harmed. The inequity of this situation is well illustrated by the sufferings among ranchers in the Waterton sour gas field who have been forced to fight two multi-national corporations with large resources, in an effort to obtain recompense for the disruption of their lives following the location of two sulfur extraction gas plants. These people were unprepared and unable to undertake the necessary documentation of scientific facts which could have enabled them to substantiate their claims. In the early days they did not have access to scientists who could have aided them in their plight. Their case was not aided by the attitudes and response of certain government officials who since the first complaints were voiced in the 50's, persisted in taking the position of disproving the ranchers claims.

LACK OF RESEARCH INTEGRATION

From our knowledge of the environmental problems of the Drywood Creek district, we feel that there has not been a sufficient effort on the part of

government to ensure an integrated approach to discovering the cause of certain unexplained health problems. The basic principles of ecology illustrate that biological systems are extremely complex. A feature of such systems is the lack of obvious relationship between cause and effect. It is commonly found that cause and effect are separated both in time and place, thus to expect to find readily available answers to explain unanticipated events arising from the introduction of a sulfur gas plant in an area is to display an ignorance of the fundamental mechanisms of the biosphere.

It is the opinion of many observers that the public hearings on the environmental effects of sulfur extraction gas plants will only illuminate a small portion of what may be a very widespread problem. I thus submit that a number of surveys are needed:

1. A field survey of all the gas plant areas in the province should be made to collect data and information from residents, professionals and industrial personnel on past histories of any environmental disturbance. The purpose of such a project would be the identification of certain patterns of response in the localities of sulfur extraction gas plants. Included in the survey should be the sweet gas plants to establish whether these are as innocuous as is generally believed.

2. Livestock from sour gas areas should be purchased and thoroughly examined. Autopsy reports on animals that lived adjacent to plants should be examined to determine whether any unusual pathology was noted. A concurrent study of plant pathology should be conducted.

3. A series of monitoring surveys to examine gas plants for additional contaminats should be conducted if the above mentioned surveys reveal some repeated patterns of effect around sour gas plants. Continuous monitoring for a one year period should be used and the data so obtained should not be open to criticism on methodiological grounds. Materials balance studies for a sample of individual gas plants should be instituted with the purpose of identifying the complete range of elements which might be present in effluent streams to the air and water.

4. It should be noted that the studies as indicated above would obviously be expensive but they could be expected to reveal an answer to the question "How much environmental contamination occurs due to gas plant operations?" If new gas plants are to be constructed, if existing plants are to be expanded, and if there is to be a continuing operation of plants for the next several decades, then it is the responsibility of the provincial government to establish whether pollution problems are fact or fiction.

5. In all newly initiated studies the team approach should be initiated to ensure that data collection is complete so that the causal factors involved in any environmental problem can be more adequately determined.

FUTURE RESOURCE EXPLOITATION IN ALBERTA

Before exploiting new resources there must be investigations of the environmental impact and the public should be given information to allow them to assure themselves at the economic advantages sufficiently outweigh the environmental costs. Research on a materials balance approach should be commenced and in future the onus of proof must be transferred from the private citizen to the corporate body wishing to exploit a given resource.

Don Gill

Associate Professor

CONSUMERS' ASSOCIATION OF CANADA

ALBERTA PROVINCIAL ASSOCIATION

BOX 5112, EDMONTON 51, ALTA.

SUBMISSION
TO THE
ENVIRONMENT CONSERVATION AUTHORITY
RE THE
ENVIRONMENTAL EFFECTS OF THE OPERATION
OF
SULPHUR EXTRACTION GAS PLANTS

Alberta Association
Consumers' Association of Canada
Box 5112
Edmonton, Alberta.

October 19, 1972.

The Consumers' Association of Canada is a voluntary, non-profit, non-political association which strives to provide information for the Canadian consumer, to study his problems and seek a solution, to provide a liaison between government, trade and industry, and to be the voice of the consumer. There are over 90,000 members of our Association in Canada, of which 9,000 are Alberta residents.

The drafting of a brief on a subject as complicated as the "Environmental Effects of the Operation of Sulphur Extraction Gas Plants" should really be prepared by people from a chemistry and/or engineering background, and we are sure you have received many briefs from such highly qualified persons. Since we of the Alberta Consumers' Association, do not, at this time, have such resource persons, we will base this brief on the right of every person to a healthy environment, and the right of future generations to their fair share of our non-renewable resources.

Defining consumer rights and articulating the basic goals of consumer protection should surely have a place in this hearing. Consumer protection is a relatively new field, but we feel he has a right to accurate information as to price, contents, quality and safety of the product and service he is buying. Freedom in the marketplace is more than the right of business to sell the public whatever it can. The establishing of provincial and national policies in the environmental fields will not be any easy task. Such regulations will interfere with what many companies have felt was their right to use and abuse our air, water and land resources - a right which until recently, a lethargic public and government has allowed them to exercise without question.

In reading through the report by Dr. R.F. Klemm, we find ourselves feeling concern about the effect of convective storms in Central Alberta (P. 48). Concerned that sulphur dioxide in rain water is above world wide background of 0.5 mg/l, and we find no comfort in the fact that it is below the values for industrial areas of North America. Sulphur dioxide is trapped within a rain storm, falls to earth as a sulphate, which is itself a soil pollution suspect. Nor do we find comfort in the fact that almost no research has been done in the area of what happens to sulphur dioxide emissions during the winter months -

especially as our winters are rather prolonged, and as this is also the season when gas plants are operating at near full capacity! There is reference made to the use of 'flares' to burn off sulphur content. The use of 'flares' on burn pits is mentioned. There seems to be some doubt as to how effective these methods are, yet failure of either, or both, of these methods, to do what is intended, could affect man and/or his environment - now or at some later date. The last paragraph on page 60 raises the question, in our minds, as to how many resident complaints must be received before an investigation is carried out? If the time lag is too great, a change in seasons could, in a sense, destroy the evidence. On page 89 we learn that a person's medical history does not follow him when he changes jobs, or employers, within the gas industry. Why? This is an age of transient life for workers within many different types of companies. School boards and public health clinics manage to cope with large numbers of transient pupils - surely the oil and gas industry with their vast computer resources could find a way. How many workers have had to leave their jobs becuase of oil industry health problems? Who knows?

As we read and searched for more information and facts on air pollution; one book with this information is "Only One Earth" by Barbara Ward and Rene Dubos. This book was used as background material for the United Nations Conference on Human Environment, and from page 104 (paper back edition), we quote: "By our relative neglect of external diseconomies, by treating air and water as 'free goods', we have accustomed ourselves to a method of measuring our wealth which gives all the 'goods' and tends to leave out all the 'bads'. Indeed, it includes such irrationalities as making no subtractions for days lost or lungs congested but included as a 'good', doctors' earnings for putting the trouble right." How can consumers know what they are paying or losing as a result of unclean and perhaps dangerous air? What value are the figures quoted as the G. N. P.?

There is much food for thought in Dr. Klemm's report. Technology has made possible a fast growing gas industry, but it would appear that the same technology has not worked as hard to control the industries' effects on the surrounding environment. Are we to be content with

statements like - 'there appears to be no damage to plants in the area'; environmental damage from sulphur dioxide in the Whitecourt area was described as 'mild' and 'transitory' - what measure was used to arrive at the word 'mild'? If it is 'mild' now, how will it be described five years from now?

We accept the fact that industry make a reasonable profit on their returns, but not if the profit is made at the expense of losing more clean air than is absolutely necessary, nor if those living near the plants feel their lives and their livestocks' lives are in danger.

John Kenneth Galbraith, an economist makes the following statement in the Weekend Magazine, March 21, 1970: "Giant corporations create their own demands to serve their own interests. These firms do not wait to be instructed by the consumer; indeed given their investment in plant and organization they cannot afford to be subject to the whims of the consumer. Instead they set their prices and go on to persuade the consumer as to what he should buy". Only you, and I, as consumers can apply the brake - start now by refusing to purchase all those extras that advertisements tell you, you need for the 'good life'. If you and I continue to enjoy the 'good life' there will be no joy in the lives of future generations. We must act now - the cost of not acting will be far greater than anything we have yet imagined.

MEMORANDUM

R.R. 2
Red Deer,
Alberta.

CONSUMERS' ASSOCIATION OF CANADA
ASSOCIATION DES CONSOMMATEURS DU CANADA

TO
A W. A. Flook

DATE Oct. 19, 1972

FROM
DE Mrs. Allan Brock

SUBJECT
SUJET

Enclosed with copies of our brief are letters from residents who live near the two plants out from Rocky. Mrs. Bjorge is a member of CAC who did this on her own time as she felt that what these people had to say was worth going out to get at their homes, as they didn't have time to leave their harvest to come to the hearings. As you can see no one has read them since she took the statements from them; she has put each in its own envelope except for Mr. Graham's which she got later and sent to me in a letter.

I am truly sorry someone from our Association was not there to present our brief but if at anytime in the future we can be of assistance we will try out best to help.

Mrs. Allan Brock.

Provincial President

Statements received by Mrs. Bjorge:

1. The odours during the night seem to be quite bad. This occurs periodically

a. to cause headaches in mornings after gas spills

b. about six mornings in the last month noticed by hired help, severe enough to cause nausea.

2. So far no increase in cow abortions.

3. Gulf became operations in 1970, Aquitaine in 1971. Aquitaine allowed large volume of raw sewage into Moose Creek, it flows into Prairie Creek while building of plant.

4. Oil noticed in the creek.

5. Farm machinery seems to rust very easily now, years gone by this wasn't a problem.

Silverware (tea pots, trays, etc.) turns dark faster than before.

The above points were brought out by Mr. Graham while talking to him.

Karin Bjorge

In her note to me another point Mr. Graham had mentioned was his concern about the sulphur build-up in the soil over the coming years. He had also seen flecks of dark material fall on his farm after an explosion at the plant.

Mr. Roger Graham,
R.R. 2,
Rocky Mt. House, Alberta.

Since the plant came into operation,it turns some of the silverware black; also money in my purse. Sometimes foul odor.

Dorothy Matchett

Dorothy Matchett,
Box 1527,
Rocky Mt. House, Alberta.

Six miles east of plant.

1. Has noticed smell in the spring of this year, whenever there's a west wind.

1 1/2 miles west of Gulf Plant.

2. Machinery seems to rust more since the plants began operating.

Are considered to be in the river valley.

Joan Smith

Joan Smith,
R.R. 2,
Rocky Mt. House, Alberta.

1. Lately strong odor causing eyes to sting.(Sulphur smell).

2. Silverware is tarnishing - silverware has to be polished twice a week. Years gone by approximately polished three times a year.

3. Farm implements are rusting faster than they did in the past.

Annie Gabler

Annie Gabler,
R.R. 2,
Rocky Mt. House, Alberta.

Three miles east of Gulf
Plant.

Rusting overnight of cylinders.

Welding shows rust spots from moisture over a short period of time.

Ron Smith

Ron Smith,
Rocky Mt. House, Alberta.

Seven miles east of plant.

1. Sense of smell deteriorated.

2. Rusting farm implements not covered by paint (eg. axe, plow) within a day.

3. Odor from plant.

4. Calves seem to have scours more this spring (not sure of the reason).

Harris Smith

Harris Smith,
Box 114,
Rocky Mt. House, Alberta.

Seven miles east of plant.

1. A bit of rusting in machine sheds.

2. Department of Environment took readings for one and a half months. No reading.

Bruce Graham

Bruce Graham,
Rocky Mt. House, Alberta.

One and a half miles east,
and one mile north of plant.

1. Rusting of dishes - couple of days if left out on the ground.

2. Three head of yearlings died from clover bloat. Grass was planted by the gas plant along their access road on approval of forestry.

3. When a westerly wind - strong odor causing eyes to burn.

4. Scours seem to affect about 40% of the herd the last two years. Before this scours was hardly heard of.

5. Pipelines and access roads open up range land so that the cattle use them and gradually follow them wandering into other people's ranges. These cause herding problems.

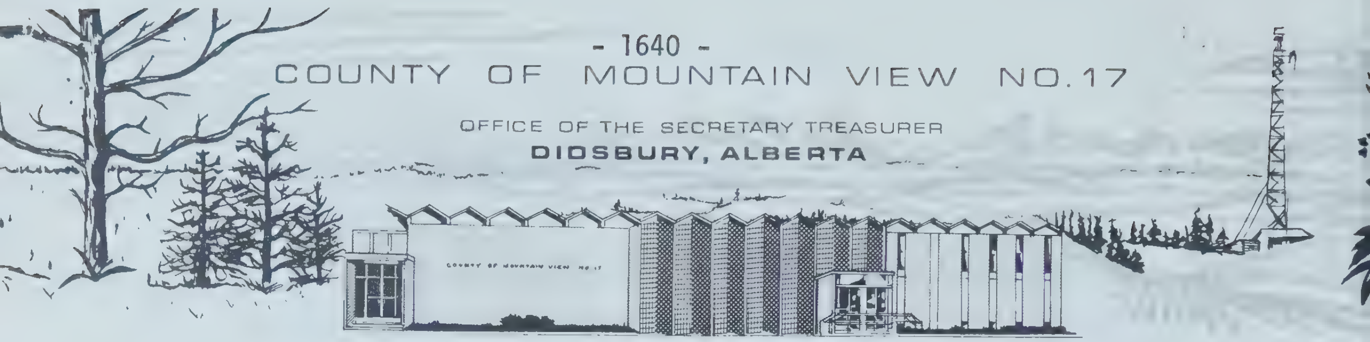
C. J. Sever

Clifford J. Sever,
R.R. 2,
Rocky Mt. House, Alberta.

Two and a half miles east
of the Gulf gas plant.

COUNTY OF MOUNTAIN VIEW NO.17

OFFICE OF THE SECRETARY TREASURER
DIDSBURY, ALBERTA



P.O. BOX 100

TELEPHONE 335-33

3rd November, 1972

Chairman,
Environment Conservation Authority
Government of the Province of Alberta
9912 107th Street
EDMONTON, Alberta

Dear Sir:

The County of Mountain View No. 17 did not make a formal presentation of its case to the Board Hearings in Calgary recently because it was felt that an earlier presentation, made to the Energy Resources Conservation Board in March of this year, would be available to the Board. However, I am advised that this may not necessarily be the case and a copy of the County's Brief should be forwarded directly to you in order that it may be considered during your deliberations, as a result of the Province-wide hearings you have recently concluded.

The enclosed Brief, while more specifically addressed to the conditions surrounding the Harmattan - Elkton Gas Plant, relates to the activities in a general way to all petroleum and natural gas plants in the County.

It would be appreciated if the contents of this Brief could be studied and included with the other submissions you have already received.

Yours sincerely,

W. J. Bagnall,
Reeve

WJB:nt
enclosures

cc: Mr. A. W. Goettel,
Head, Soils Branch
(w/o enclosures)

COUNTY OF MOUNTAIN VIEW NO. 17

OFFICE OF THE SECRETARY TREASURER
DIDSBURY, ALBERTA

. BOX 100 TELEPHONE 335-33

WITHOUTH PREJUDICE 28th March, 1972

Energy Resources Conservation Board
Oil and Gas
603 Sixth Avenue Southwest
CALGARY, Alberta

Dear Sirs:

In the Matter of Harmattan-Elkton Field
Canadian Superior Oil Limited Application
for Exemption

and

In the Matter of an Energy Resources Conservation Board Informational Letter No.
I L 71 - 29, dated 9th November, 1971,

The Council of the County of Mountain View No. 17 strongly opposes any exemption from the provisions of the Informational Letter No. I L 71 - 29, insofar as the application of the Canadian Superior Oil Limited is concerned.

The Canadian Superior Oil Limited has a long history in the County of Mountain View of atmospheric contamination and ground level pollution. The County Council since 1966 has received complaints from residents of the area in the vicinity of the Harmattan-Elkton Gas Plant respecting damage to paint work on buildings, damage to foliage, trees and growing crops. The effects of the emissions from this plant, have been detrimental to the health of residents of the area and to livestock.

Any increase in the allowable emissions which, it is respectfully suggested, are altogether too generous now, must be bitterly opposed. It is requested that the Board take into consideration the highly noxious character of this particular plant which, it is understood, is one of the most noxious in Central Alberta.

WITHOUT PREJUDICE

Energy Resources Conservation Board

In support of this opposition, the following documents are attached:

Minutes of County Council meeting January 25, 1967;
Copies of Correspondence between the County of Mountain View and the Department of Health - Environmental Services;
Copy of Informational Letter No. I L 71 - 29;
Miscellaneous Relative Correspondence

County Council is aware of a report prepared on 27th of May, 1965, by Barry and Richardson, Consulting Engineers, on behalf of Canadian Superior Oil Limited, and it is submitted that this report endeavours to 'play down' the seriousness of the noxious gas emissions of this particular plant, and that if this plant were located close to an urban centre, such emissions would not be permitted nor tolerated.

In the light of the experience of this County Council relative to the air pollution in the Harmattan-Elkton area, Council cannot too strongly emphasize the need for greater restrictions and more adequate controls than are presently being exercised in this field.

Respectfully submitted,

W. J. Bagnall,
Reeve

WJB:nt
enclosures

County Council - January 25, 1967.

Sundre General Hospital District #51

A discussion followed regarding the establishment of the Sundre General Hospital District, at which time Councillor Hosegood commented that these hospital Districts are laid out by the Department of Health after long study of reports they get in from the adjacent hospital districts - "and I think you will find the Sundre Hospital District has been set up and the boundaries have been defined and finalized by ministerial order in Edmonton after long consultation with the Department of Health. I think they have laid out this district and must feel it is necessary or they would not put it there. It will not make any difference in the hospitalization -- people going to the various hospitals now will continue to do so."

Councillor Pekse stated that he believed possibly 90% or more in that area are in favour of the hospital in Sundre. "I cannot see why we are concerned as much about it as we appear to be because the Provincial Government has decided to build the hospital there after a lot of research and study. I think we should approve the boundary and appoint the three representatives from the area."

Motion #70

Moved by Councillor Pekse the county council accept the program as proposed by the Department for the establishment of the Sundre General Hospital District #51.

At this point Messrs. Dobko and Hogge of the Department of Health, Dr. Keys of the Mount View Health Unit, R. Pillidge, Mount View Health Unit Sanitary Inspector and Mr. L. Purdy of the firm of Fisher, Fisher, and Lockwood, met council as per appointment to discuss the matter of air pollution. The matter of the General Hospital District at Sundre was therefore tabled for discussion later in the day.

The reeve declared the council meeting adjourned, to meet as a committee of the whole to discuss the matter of air pollution.

Air pollution

The reeve advised the Department of Health representatives that the county council is quite concerned about the operation of the Harmattan-Elkton plant and understands that for some time the Department has been undertaking various tests; further that council is led to believe from information which has been provided, that conditions close to the plant are not greatly improved -- that a very dangerous form of gas is being released to the detriment, well being and health of people in the immediate area, particularly to the north of the plant. He asked for the re-action of the department.

Mr. Hogge commented that the company has operated the plant for some 5-6 years now, and then about a year ago they proposed to start producing some of their sour gas wells - previously produced relatively sweet condensate wells. The sour gas wells meant there was going to be enough sulphur in the gas as it was produced to require a sulphur recovery section on the plant. So the company submitted its plans to the department as required, which were reviewed and approval issued. The plant started operating sometime in September and had some start-up problems, so the first complaints received by the department on the operation of the sulphur section was through R. Clark, M.L.A. for the area, which was the latter part of October. "About the middle of November we managed to get one of our air pollution monitoring trailers put in the area (Nov. 23) and kept it there until Dec. 16th. It has been our annual practice for general overhaul. So we followed this practice, and it was felt we should put it back out in the area, which we did, and it has operated there since and is still there. About the middle of December the complaints were becoming more severe and we arranged a meeting with the company in Edmonton on December 19th and discussed the whole situation with them and explained the complaints received and asked them to take whatever steps they could to insure that the complaints were not justified.

After that the plant had been up and down but it started up again about December 16 and actually there were no complaints until the early part of January - about the 5th but for 4-5 days we got a number of complaints and the data on our unit showed there were fairly high concentrates of sulphur dioxide. The plant was shut down on the 14th and started up on the week end, so it has been operating since the 22nd according to our information and again we would assume there are no complaints from the 22nd to the present. We drove around the area this morning and there was nothing objectionable this morning. One day of the month does not necessarily mean this is a representative condition. I think that is about the situation as we see it right now.

Reeve: We have had interviews with the farmers and know their position. You apparently agree then, Mr. Hogge, that this plant is kicking out highly dangerous material, but really nothing has been done about it. The off again - on again situation is not very staisfactory, is it?

Mr. Hogge asked if the company had been invited to attend this meeting so they could explain their technical problems. The reeve assured him they had been invited to send a representative to the meeting - "further they were at a previous council meeting and explained their technical problems which we realize, but that is their problem. We do not feel they should be permitted to operate the plant under these conditions."

Dr. Keys outlined the problem as he understood it.

Mr. Hogge: In any of these plants there will be things go wrong, the same as on a combine. It is only by the vigilance of the operating staff these things can be kept under control. When they get the extra separator they can set up a maintenance program so they can switch from one to the other.

Dr. Keys: Once they have this I think we have a better guarantee we are not going to get these excessive pollutions, but until that time I do not think we have any guarantee the same thing will not happen again.

Mr. Hogge: Those in January went on 4-5 days and we think that was

an excessive period of time. We thought then this should have been found sooner, and that if they have trouble it should be shut down until under control. They have now advised us this will be done, and they will have the plant patrolled downwind to see if there is any irritation being released, which is the only way they can operate the plant. They can correct one thing and something else will likely go wrong afterwards. It is only by the vigilance of the operating staff they can keep this under control.

Reeve: Is this good enough for the individual actually suffering out there? We are dealing with people's health and lives now.

Mr. Hogge: The company is operating monitoring units itself and with patrols around the plant I cannot think there should be any offensive air or adverse conditions created which are not detected.

At the request of Mr. Purdy, Mr. Hogge tabled correspondence between the company and the department: copies of which were taken for the county files.

Reeve: It does seem from our point of view that the company is not making as much effort as it should be in remedying the situation which has been going along now for well over two months. The most affected parties will have to move out of the country - they cannot continue to live under these conditions and carry on their farming enterprise. We do not know how many people are being injured without really knowing they are by breathing in smaller quantities of this air which surely cannot be very healthful.

When questioned by Mr. Purdy, Mr. Hogge stated there are a number of sour gas plants in the province: Carstairs and Olds -- the only difference between this particular one and others is the percentage of hydrogen sulphide in the raw gas is higher at the Harmattan-Elkton plant.

Mr. Purdy: Was this known at the time of the application?

Hogge: Yes.

Mr. Purdy: Was there any indication they would experience any different procedures than other plants -- that they would need different

equipment to deal with this particular type?

Mr. Dobko: No. They would be operating in a fashion that complied with our requirements. Unless there was some basic difference in the design of the equipment which we do not enter into, the processing seemed to be the same as any other sulphur plant drilling in natural gas with any amount of hydrogen sulphide in it.

Mr. Purdy asked for a copy of the submission and asked if it was amended on the request of the department, to which Mr. Dobko replied that offhand he did not recall that there were any major differences the department had felt would be necessary. He submitted a copy of Waste Gas Disposal Study for the Harmattan-Leduc D-3 Gas Processing Plant (Harmattan-Elkton) dated May 27, 1965 prepared by Barry and Richardson, Calgary, and was assured by the chairman this document would be kept confidential. Mr. Hogge commented that one of the other things discussed with the company in detail was the operation of the gas wells themselves. "They have a problem with the production pipes in the well plugging up with sulphur and about once a year this has to be dissolved to get the gas up. They have a certain procedure for doing this and the liquids left over when the operation was completed was burned in the pit, together with the gas from the well, for a certain time before going into the pipe again. I do not recall all other aspects but this flare pit was not known to be much of a problem at that time.

Mr. Dobko remarked the company was apparently attempting to bring in one well which proved to be quite a problem and in bringing in a well they have procedures they follow -- "there were a large number of flarings made from the well beyond the usual manner in which a well is brought in. Since then, I understand, they have completely shut in the well and will not attempt to produce it."

Mr. Purdy: Then part of the problem could have been trying to bring in the other well?

Mr. Dobko: From the interviews made with people in the area we are able to determine that part of the effects were because of the well operation.

Mr. Hogge mentioned that one of the flares had gone out and this had been noticed over quite a considerable area. Since that time the company has made sure that someone was there to watch the flares and shut the well down if flares go out.

Mr. Hogge outlined the operation as shown him by Mr. Schlanka, mentioning that freezing pipes had made it necessary at one time to use the flare pit.

Dr. Keys: So if it freezes again they will again burn in the pit?

Mr. Hogge: The only safeguard we have on that is the operators watch it and make sure it operates normally - if it does not operate normally they will shut the plant down. The Plant Superintendent told us this morning he understood this is the instruction, and our correspondence confirms that he is prepared to do that.

Mr. Purdy: Normally speaking, if that unit broke down would it not be obligatory for your department to shut down, but you leave it to the plant to police it. Their proper procedure would have been to shut the plant down immediately rather that use the flare pit?

Mr. Hogge: mhm.

Mr. Purdy: You would agree they were in error in keeping up production?

Mr. Hogge: The plant say they have to operate to determine the weaknesses and pit falls they will encounter. We have explained to them in no uncertain terms they must supervise the operation so abnormal things do not continue to happen. As I explained earlier, regardless of how many things were fixed on the plant there will be new things coming up, and they are the only people who can assure the plant operators without nuisance to others.

Reeve: From what you have told us Mr. Hogge, you do not feel you could give us positive assurance that these conditions will not repeat themselves at this plant?

Mr. Hogge: No, we have the assurance of this company they will not, but the company is operating the plant and the company has to be responsible for this. I think after there have been 2 or 3 things go

wrong, that they did not fix as quickly as we would expect them to fix them, you have to reserve judgement until they have operated for a certain time and then you know how successful they will be in operating the plant without nuisance. Our information is that the plant did operate successfully and without nuisance or bother to residents between the middle of December period and early in January.

Hosegood: That is not right sir.

Mr. Sheehan commented that he had been under the impression monitoring of plants would be done at all times by the department, not only when the department received complaints.

Mr. Hogge advised that the procedures for monitoring are:

When the plant is proposed we put exposure cylinder stations for detection of hydrogen sulphide, which were put out at the time the first plants were put up. We put some more in when the sulphur section was added.

In addition to that we required monitoring of gas in the air by the company. In addition to that we have two mobile laboratories ourselves which are used to monitor the various plants throughout the province and our program is to be in the vicinity of these plants twice a year whether we get complaints or not. When we get complaints we endeavor to re-arrange our schedule to get our units into the area where the complaints are coming from. We do have this basic monitoring program to check on the operation of the plant and get information from the company. The cylinder put out gives general monitoring conditions over the month but our trailer is necessary to get information on a specific basis.

Upon questioning by the reeve Mr. Purdy stated: I think Messrs. Hogge and Dobko have established they have been after the company in the interests of the county, but the problem breaks down from the point of having to police it.

Mr. Hogge: Basically we do not assume any responsibility for the operation of the plant. The company owns the plant and if they do some damage to someone by the operation of the plant, they themselves are wholly responsible for the damage. We make every effort to detect

any abnormal condition and to insure if anything improper does happen it is corrected and does not happen again in the future. This we have been following up pretty closely, but I do not feel we can give you any assurance that something else will not come up that will create a problem. We would appreciate knowing anything that comes to your attention that something is wrong. We will continue to have our trailer at Rindals locations until the end of the month.

Dr. Keys asked if the trailer could be left on location until the new separator is hooked up and ready to work, and Mr. Hogge stated that it could.

Councillor Hosegood asked if the department had instructed the company to cease operation of the flare pit.

Mr. Hogge: No, we did not tell them to cease operation of that but to operate the plant in a way that would not inconvenience the people. "We indicated they had to make other arrangements to what they were doing. It was as a result of discussions at the meeting they made the changes they have made."

Mr. Dobko stated the plant would not be able to operate without the pit.

Mr. Hosegood: I did not mean total cessation of the pit - but stoppage of putting this particular material into it.

Dobko: That is right. So far as we have determined from our monitoring and personal investigating at the plant, the root of the problem is that pit. As of this morning it is understood they have all of their sections operating as per ordinary operating conditions and the sour water is being stripped so there would be relatively sweet water going to the flare pit.

Mr. Hogge stated it is his understanding that if the pipes freeze again the plant will be closed down. "I personally think they will insure they will not repeat what they had the first of January."

Dr. Keys asked Mr. Hogge if he could be kept informed of any important correspondence in this matter, and Mr. Hogge agreed to supply same. Mr. Hogge further advised that any data they have on file

would be made available to the county if and when requested.

The delegation withdrew at 2:30 p.m. after the chairman expressed appreciation of their cooperation.

Mountain View Hail Suppression Association

The county council meeting reconvened at 2:35 p.m. with some 25-30 ratepayers in the galley.

Mr. J. Good, accompanied by a delegation of 6 member representing the Mountain View Hail Suppression Association, interviewed council re: establishment of a Hail suppression area. Mr. Good explained that for some 4-5 years the Mountain View Hail Suppression Association had been carrying on a weather modification program supported by a public canvass, which has now rather bogged down. He asked the county council to provide for a plebiscite for the purpose of raising funds for a weather modification program -- requested 13¢ per acre for the program in the area proposed, which they hoped would not require more than 6 mills.

Area: All of township 29 - range 27
Part of township 29 " 28 (sections 9,10,11,12,13,14,15,16, 21,22,23,24,25,26,27,28,33,34,35, 36)
All of township 30 - range 27
Part of township 30 - range 28 (sections 1,2,3,4,9,10,11,12,13, 14,15,16, and 21-36 inclusive.)
Part of township 30 - range 29 (sections 25,26,27,34,35,36)
Part of township 30 - range 1 (sections 25 to 36 inclusive)
Part of township 31 - range 26 (sections 5,6,7,8,17,18,19,20.)
All of township 31 - range 27
All of township 31 - range 28; all of township 31, range 29; all of township 31 in gore strip; all of township 31, range 1; all of township 31, range 2; and all of township 31, range 3.

CANADIAN SUPERIOR OIL LTD.

703 SIXTH AVENUE S.W.

CALGARY, ALBERTA

AREA CODE 403
267-4110

November 17, 1966

Government of the Province of Alberta,
Department of Public Health,
Division of Sanitary Engineering,
Administration Building,
EDMONTON, Alberta.

Attention: Mr. S. L. Dobko, P. Eng.,
Head, Air Pollution Control Section,

Dear Sir:

Re: Harmattan Leduc (d-3) Gas Processing Plant
Your file No. 284

In reply to your letter of November 10, 1966, we submit the following information.

Initial start up of the Harmattan Leduc Plant was September 14, 1966. After four days operation, an explosion in the plant start up boiler shut the plant down and left one sulphur train with quite a bit of sulphur in the catalyst beds which solidified after cooling. After repairs were made to the start up boiler, the plant was again placed on stream on October 15, 1966. At this time, the sulphur train with the sulphur in the catalyst beds was cleared by controlled burning. This "burning off" of the sulphur could have caused the heavy bluish haze from the stack.

We have also encountered problems in flowing the field wells at uniform rates. This has caused upset conditions in the plant and has contributed to low sulphur recoveries.

Following is a tabulation of operating data requested in your letter: Efficiency figures are erratic in that four days reflect greater than 100% recovery. These seem to be from carry over production from

a day either before or after the calculated day (Sulphur production is gauged in a pit and may not be gauged at exactly the same time each morning - this will be corrected).

Yours very truly,

CANADIAN SUPERIOR OIL LTD.

B. D. Garrison Jr., P. Eng.,
Supt. Gas Operations

BDG:cm
Attach.
c.c.: A. Shklanka (2)

OPERATING DATA

Harmattan Leduc (D-3) Gas Processing Plant (1966)

Date	Sulphur Production Long Tons	%Recovery	SO_2 to Atmosphere Long Tons	Stack Emission Temp. Max.	Min.	Avg.
Oct. 15	201	134.4	-	1280	1090	1185
16	266	77.6	253	1290	1100	1195
17	299	63.5	343	1310	580	945
18	550	105.6	-	1340	1140	1240
19	488	83.8	188	1280	1240	1260
20	463	91.8	83	1340	1180	1260
21	400	79.3	209	1440	1060	1250
22	500	96.7	34	1440	1120	1280
23	492	96.8	32	1220	1150	1185
24	456	72.0	354	1350	710	1030
25	637	91.7	114	1300	1110	1205
26	502	80.2	248	1280	970	1125
27	251	86.0	82	1310	1050	1180
28	445	102.4	-	1280	1000	1140
29	283	84.9	100	1120	1040	1080
30	267	86.9	80	1600	1000	1300
31	219	82.9	90	1530	620	1075
Nov. 1	309	73.1	228	1400	1160	1280
2	568	89.8	130	1350	1180	1265
3	789	110.8	-	1290	1140	1215
4	579	91.3	110	1240	1130	1185
5	484	86.4	152	1320	1150	1235
Total	9,448					
Average		88.6	108	1332	1042	1189

Department of Public Health

H. L. Hogge, Director,
Division of Sanitary Engineering.

Hon. J. Donovan Ross,
MINISTER OF HEALTH.

November 18, 1966.

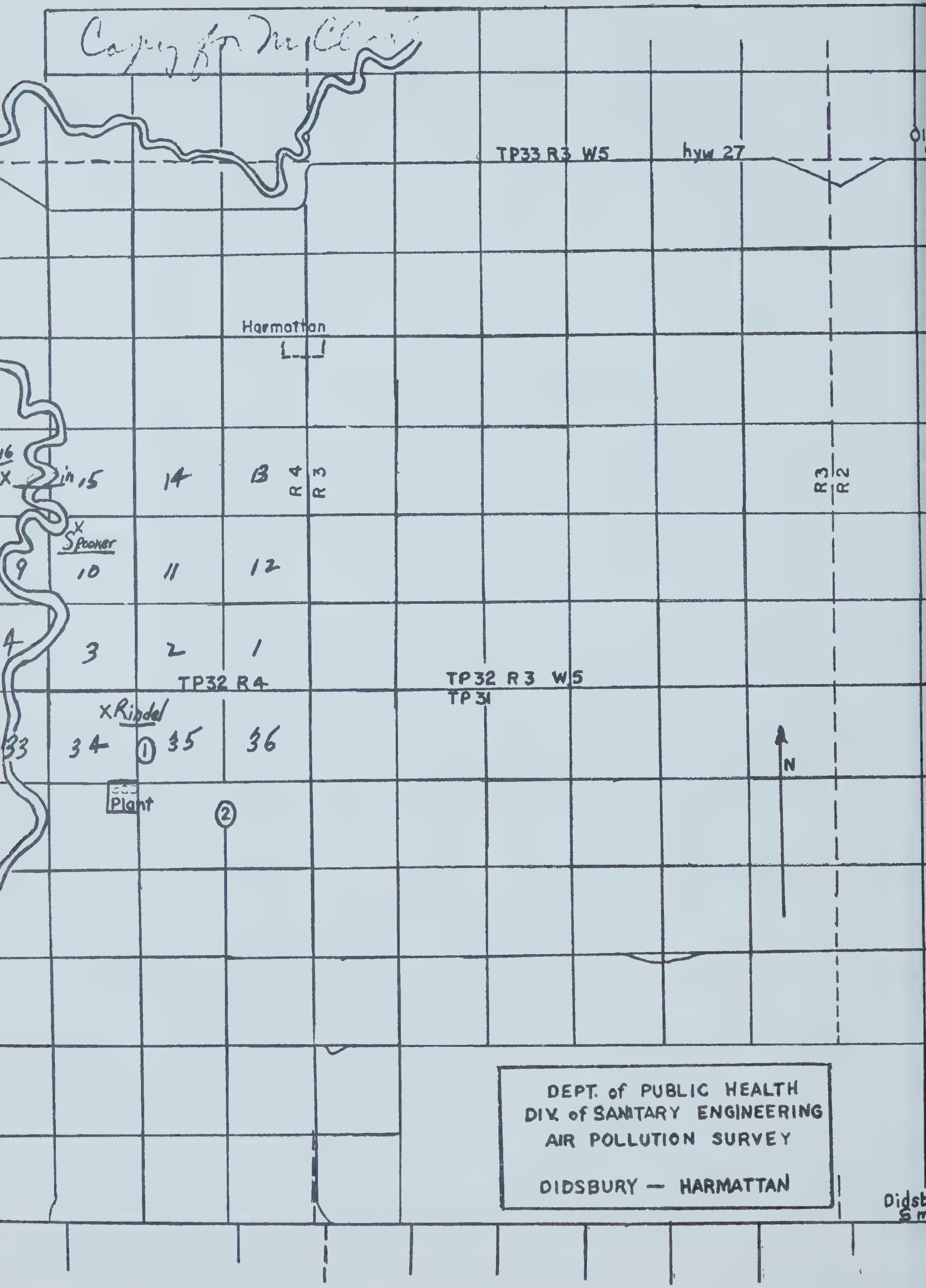
Re: Complaints of Air Pollution,
Harmattan-Elkton Area

We are pleased to forward the following information on the air pollution complaints from this area. The original complaint was from a Mrs. W. E. Braden to the Honourable R. C. Clark. Mrs. Braden resides in the E½ 16-32-4-W5. This is in the gas field area and it was felt that this complaint was not related to the plant operations. A copy of our report on the November 3rd investigations is attached hereto. We have written to the Oil and Gas Conservation Board with respect to the operation of the gas wells themselves. We had also written to Canadian Superior Oil Ltd. regarding the operation of their plant and a copy of their letter of November 17th is attached hereto. It is apparent that unusual start-up problems have been encountered at this plant, however these should not continue for any appreciable length of time. We have moved one of the air pollution trailers to a location near the gas plant and will also be operating the trailer at, or near, the Braden residence in the next three weeks. The hydrogen sulfide sampler will be operated in the gas field area during the times that the trailer is near the plant. We should have a report on the trailer operations about the middle of December. We are also enclosing a copy of a map showing the location of the gas plant and the residences mentioned in the complaints.

Respectfully forwarded.

H. L. Hogge, Director,
Division of Sanitary Engineering.

HLH:ad
Encls.


TP33 R3 W5
hyw 27
Harmattan
R4
R3
R3
R2
15
14
13
Spooner
10
11
12
3
2
1
TP32 R4
TP32 R3 W5
TP31
Riddel
34
35
36
Plant
N
DEPT. of PUBLIC HEALTH
DIV. of SANITARY ENGINEERING
AIR POLLUTION SURVEY
DIDSBURY — HARMATTAN

- 1657 -

ITEM 187

PROVINCE OF ALBERTA

RECEIVED

NOV ... 1966

In the Office of the

MINISTER of YOUTH

MEMORANDUM

OUR FILE NO.:

YOUR FILE NO.:

FROM: Minister of Health

TO: The Honourable R. C. Clark
Minister of Youth

DATE: November 21, 1966

Re: Complaints of Air Pollution -
Harmattan-Elkton Area

This will acknowledge your memorandum of November 14th with reference to a complaint of air pollution from the Harmattan Gas Plant made to you by a Mr. Ed Rindal, located on the NE-34-31-4-W5, by telephone.

I am attaching copies of information made available to me by the Director of the Division of Sanitary Engineering, whose responsibility it is to administer the pollution control program of the Department of Health.

I trust that this information will inform you of the action that has been taken in regard to this particular petro-chemical operation.

J. Donovan Ross, B.A., M.D.
MINISTER OF HEALTH

att

c.c. Mr. H. L. Hogge

GOVERNMENT OF THE PROVINCE OF ALBERTA

DEPARTMENT OF HEALTH
Environmental Health Services Division

303 Administration Building,
Edmonton 6, Alberta.

February 4, 1969.

Mr. F. J. Dawley,
Municipal Secretary,
County of Mountain View No. 17,
DIDSBURY, Alberta.

Dear Mr. Dawley:

Thank you for giving us the addresses of the residents of the Harmattan-Elkton area. We are today forwarding a letter to all of the people on the list and a copy of the circular letter is enclosed as information. Mr. S. L. Dobko will have explained to you yesterday that we had telephone complaints from Mrs. Bond, Mrs. Wigley and also a Mrs. R. H. Ross. The report was that strong odors had been noticed in the area between 2:00 a.m. and 8:00 a.m. in the area east and northeast of the plant Sunday morning, February 2nd. Further follow-up is still to be made in this regard. We will continue to follow up complaints from this area and should matters come to your attention which you feel we should be aware of, or which we should investigate, we would be glad to hear from you.

Thanks again for your assistance.

Yours very truly,

H L Hogge

H. L. Hogge, P. Eng., Director,
Environmental Health Services Division.

HLH:ad

Encl.

GOVERNMENT OF THE PROVINCE OF ALBERTA

DEPARTMENT OF HEALTH
Environmental Health Services Division

303 Administration Bldg.,
Edmonton 6, Alberta.

February 4, 1969.

Dear Sir:

Concern About Air Pollution in the Harmattan-Elkton Area

There has been a considerable amount of publicity given to possible air pollution problems in your area and we would like to forward the following information to you on this subject.

We have carried out a thorough review of our files and find no reports of possible adverse effects since August of 1968, some six months ago. Also, our files include details of air quality monitoring and gas plant and gas well operation and note that there is nothing that would indicated any excessive release of air contaminants during this time. It is, of course, necessary to investigate any adverse effects very quickly or else the important and required evidence cannot be obtained or assessed. We have also checked with the Veterinary Services Branch of the Department of Agriculture and are advised that they, too, have not been advised of any possible adverse effects since August of 1968.

For a number of years now we have carried out an active air pollution control program including the detailed investigation of any reports of possible adverse effects both in the Department of Health and in other Departments of the Government. We would recommend that if, at any time, you become concerned about possible adverse effects of air or water pollution at your farm, you advise us promptly, preferably by a collect telephone call, followed up by a confirmatory letter in the mail. All calls could be directed to our Division at 229 - 4551, Edmonton, or if you wish to contact the Veterinary Services Division directly you could phone them at 433 - 7418, Edmonton. We would point out, however, that where there is illness or

death in livestock, your own Veterinarian should be contacted first. The Veterinary Services Division is, of course, prepared now as in the past to investigate in detail death or illness in livestock which is suspected of being associated with pollution. If you can provide information as to what the nature of the adverse effect is, the time that it occurred, and any wind direction that you may have noted, this will assist in the prompt investigation of your report. In the case of the operation of oil or gas wells and the associated batteries, you could contact the Red Deer Office of the Oil and Gas Conservation Board at telephone number 346 - 3679, Red Deer.

We would like to let you know also about some of the work which the Government and the Gas and Oil Companies in Alberta are doing to ensure that air pollution is adequately controlled to ensure that there is no adverse effect on other people's property. The companies must obtain from the Oil and Gas Conservation Board, approval for the location and drilling of any oil and gas well and, if the well is productive, the operation of the well must conform to the Board's regulations and this is supervised by field engineers stationed throughout the Province. The gas processing plants must obtain approval from the Provincial Board of Health with respect to their location and the method and rate of release of any waste gases to be released to the atmosphere. Before approval is given the process design and the amount of materials being handled is checked and calculations made to predict the concentration of any of these waste gases at ground level in the area. The method of release must be such that the waste gases will be adequately dispersed before they would reach ground level. Also, the conditions contained in the approval require that the companies maintain a continuing check on the release of waste gases including the following specific items:

(a) Maintain a daily record of the amount of materials they are handling and the amount of waste materials released.

(b) They must provide an air monitoring system consisting of at least a number of exposure stations which are changed monthly, and in the case of larger plants, including the Harmattan-Elkton plant, they provide instruments which will continually sample the air and analyze it for the main contaminants.

The companies forward this information to us for review at least on a monthly basis and in some cases on a weekly basis.

The Environmental Health Services Division maintains a number of exposure stations in the area for the detection of sulfur gases and these are changed on a monthly basis and analyzed in our laboratory. The general air pollution control program also includes continuous monitoring of the air and analyzing it for sulfur gases for periods of two to four weeks twice a year in the area adjacent to the gas processing and sulfur recovery plants,

and this is being maintained in your area. The mobile units were located in the district for a period at the end of 1967, in the spring of 1968, and in November, 1968. Also the mobile laboratory is scheduled to be in the area again at the first of February this year.

As mentioned previously, the program also includes the detailed investigation of any complaints of air pollution. If the complaint refers to adverse effect on livestock or crops, investigation is made jointly with the appropriate officials of the Department of Agriculture. The complaints will be investigated promptly and, of course, it is important that they reach us as soon as possible so that a complete and thorough study can be made.

Yours very truly,

H L Hogge

H. L. HOGGE, P. Eng., Director,
Environmental Health Services Division.

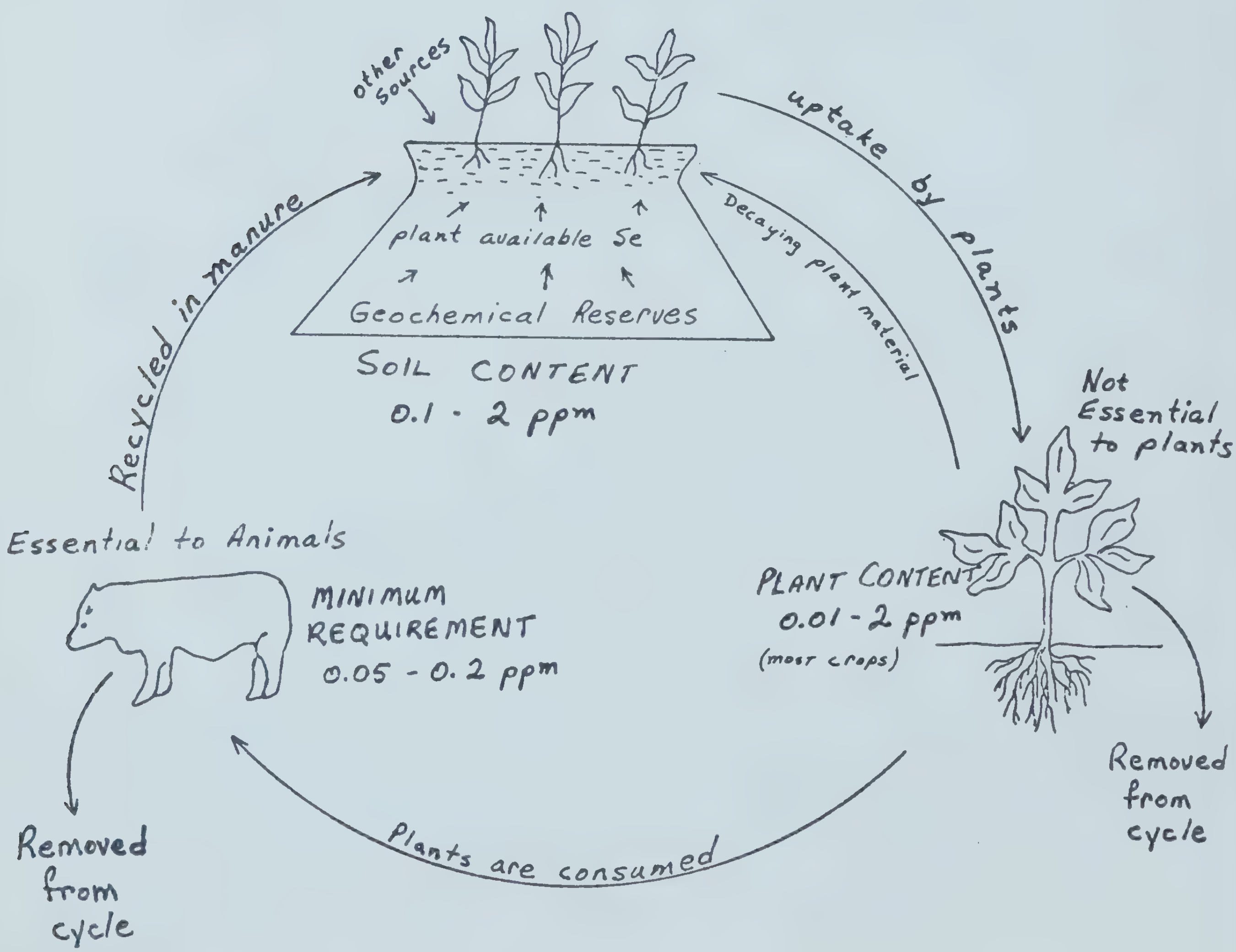
HLH:ad

PLANT INDUSTRY DIVISION
SOILS Adgex 531

D. L. Massey, Plant Physiologist
P. J. Martin, Animal Nutritionist
(Animal Industry Division)

SELENIUM

SOIL-PLANT-ANIMAL RELATIONSHIP



This report is designed to provide both basic information and progress of current work in Alberta. The report will be updated as more information becomes available.

ALBERTA DEPARTMENT OF AGRICULTURE

SELENIUM IN SOILS AND PLANTS

WHAT IS SELENIUM?

Selenium is a naturally occurring element in soils and originates in the parent material (rocks and minerals) from which our soils are formed. From what we know about soils, it is assumed that soils may vary greatly in their selenium content. It is not so much the total amount of selenium in the soil that is important, but rather the amount that is available to plants.

IS SELENIUM REQUIRED BY PLANTS?

As far as our crop plants (forages, grains, etc.) are concerned, selenium is not an essential element. Addition of selenium to the soil or foliage, therefore, would do nothing to benefit crop growth.

DO SOME PLANTS TAKE UP MORE SELENIUM THAN OTHERS?

Yes. There are numerous accounts in the literature that plant species vary in their ability to take up selenium. A group of plants called "selenium accumulators" possess an unusual ability to take up selenium. The selenium content of certain milk vetch species (*Astragalus sp.*) may be so high as to be extremely toxic if consumed by livestock. Stands of these plants may be found in scattered patches of pasture fields in several areas of southern Alberta (13,15).

As for our important forages, surveys conducted in other countries have indicated that legumes may or may not take up more selenium than grasses if the selenium levels are in the normal range (3,4,8). Among forage species, alfalfa usually contained the highest concentration of selenium. In areas where selenium levels were very low there was little difference among species, legume or grass.

WHAT ABOUT GRAINS?

There has been relatively little work done on determining the selenium content of grains and relating them to levels in forages grown on the same soil. Wheat has been shown to contain more selenium than oats or barley (1). Early work done in Alberta suggested that selenium levels can vary greatly in samples of wheat (19). Again, where levels are very low, there should be little difference in selenium content between forages and grain.

WHAT LEVELS ARE FOUND IN PLANTS?

With the exception of selenium accumulators which may contain up to several thousand ppm of selenium (Se), our crop plants usually contain 0.01 - 2 ppm (parts per million). Selenium is found in such small amounts that it must be regarded as a trace element. At very low concentrations we speak of parts per billion (ppb). It is only recently that techniques and equipment were available to measure these minute amounts. At present, however, there is no satisfactory method for measuring the amount of available selenium in soil.

HOW ARE DEFICIENCIES MANIFESTED?

Selenium is not required by plants but is essential to animals. The deficient level of selenium for animal feeds is generally considered to be in the range of 30 to 200 ppb depending on a number of factors (11). Any level below 100 ppb Se may be considered potentially deficient for practical purposes.

WHAT IS THE PRESENT SITUATION IN ALBERTA?

SELENIUM DEFICIENT AREAS?

Based on reports from veterinarians and farmers and laboratory analyses of feed samples during the past two years, we have reason to suspect that much of the area of west central Alberta from Calgary to Stony Plain and west of highway number two is potentially selenium deficient. Recently there have been reports from the Peace River area of selenium deficiency. In addition there have been sporadic cases of selenium deficiency outside the above defined areas.

SOIL TYPE?

Veterinarians have indicated that farms located on light-textured Gray Wooded soils show the greatest incidence of selenium deficiency in livestock. The Lacombe Research Station has found that forages produced on Gray Wooded soils in west central Alberta are very low in selenium (18). The A.S.F.T.L. analyzed oat and barley grain samples from plots located on Gray Wooded soils in the north Peace and only 7 of 52 samples contained more than 0.1 ppm (100 ppb) Se. The survey now in progress includes other major soil groups.

SPECIES DIFFERENCES?

The 1969 - 1970 data from Lacombe is summarized in the following table (18):

	No. Tests	Average ppb Se	
		No S	40 Lb.S.
Alfalfa	23	169	87
Alsike	38	19	13
Red Clover	30	18	11
Brome	15	29	24
Timothy	25	12	10

Alfalfa generally contained higher levels of selenium than the other four species in the study. The difference may reflect the deeper rooting characteristics of alfalfa.

In our own work this past year alfalfa has been found to contain 2 - 10 times as much selenium as the associated grass. A possible exception is Russian Wild Rye which, based on the few analyses that we have performed, contains more selenium than other grasses. Levels as low as 20 ppb Se, however have been measured in pure alfalfa in severely deficient areas. Species differences assume little importance when levels are this low.

GROWTH STAGE OF FORAGES?

There is a possibility that selenium levels, like other chemical constituents, could vary with the time of year that forage is harvested. If so, selenium supplementation in deficient areas may need to be adjusted or, alternatively, harvesting dates may be adjusted to maximize selenium levels. The present survey

will cover the effect of growth stage on selenium uptake. Work at Lethbridge with *Astragalus pectinatus* a selenium accumulator, has shown that selenium levels were much lower in the late fall than found during the summer (Dr. R. Hironaka, personal communication).

FERTILIZERS?

In sulfur deficient areas, where livestock assumes a major portion of the farm income, many farmers are not using sulfur-containing fertilizers such as 21-0-0 on pasture or hay. There is some evidence that sulfur depresses uptake of selenium by plants thereby aggravating the problem of selenium deficiency in animal feed. The preceding table (Lacombe data) points out the effect of sulfur but one important point should be noted. These tests were carried out on sulfur-deficient soils and in most cases there was a substantial yield increase in forage (18). The reduction in uptake of selenium, therefore appears to be due mainly to a dilution effect from increased production rather than a direct antagonistic effect of sulfate on selenium uptake as is suggested in some of the literature.

Our laboratory is quite concerned of the effect of sulfur on selenium uptake. Studies carried out last year on soil fertility plots in the Innisfail area did not show any significant effect of sulfur on selenium uptake even where treatments included 72 lbs. of sulfur per acre (9). Levels of selenium in forage from this area are so low (10-30 ppb), however, that further reductions would be insignificant in terms of the animal. Walker (18) has noted that the reduction was most pronounced where the selenium levels were above 100 ppb.

Our survey includes several locations where sulfur fertilizer has been applied on forage and undoubtedly further study is warranted. At this time sulfur-containing fertilizers should be used on sulfur deficient soils to provide good crop yields even where selenium levels may be low. The value of increased production will generally be greater than the cost of selenium supplementation for animals.

WHAT IS BEING DONE?

1. SELENIUM SURVEY

As mentioned earlier in the text, a selenium survey is being conducted to delineate potentially deficient areas in the Province of Alberta. This action was initiated at the 1970 meeting of the Advisory Committee of Feed Testing and will continue to accumulate several years' data.

2. HAIR ANALYSES

Selenium analysis has already been performed on a number of hair samples from calves suffering from nutritional myopathy (white muscle disease). Hair analysis may be a good indicator of the selenium status of the animal. Once enough data has been collected from "normal" and "deficient" animals, some assistance can be given to veterinarians in diagnosis of cases of suspected selenium deficiency. Such a technique should complement feed analyses in establishing deficiencies before losses are accrued through death or poor performance.

WHY DO ANIMALS NEED SELENIUM?

The suggested biochemical functions of selenium are (2): acting as a carrier for vitamin E; serving as an antioxidant; being essential in the synthesis or activation of some of the enzymes involved in decarboxylation; and being essential for the production or activation of lipase. An adequate level of selenium in a diet is necessary to prevent the following problems:

1. Myopathies (muscle abnormalities) in animals.
2. Exudative diathesis in chicks.
3. Gizzard erosion in turkeys.
4. Anemia in children

WHAT HAPPENS IF ANIMALS DO NOT CONSUME ENOUGH SELENIUM?

Problems related to selenium deficiency have been documented in Canada, United States and at least fourteen other countries. In Alberta there is a significant problem with nutritional muscular dystrophy (NMD, "white muscle disease") in some areas. Mulberry heart disease (an apparent manifestation of selenium deficiency in hogs) has also been diagnosed in Alberta. NMD may not be the most significant problem resulting from selenium deficiencies. Jordan (7) states that poor reproductive performance may be caused by low levels of selenium or vitamin E. The symptoms of "white muscle disease" ("stiff lamb disease") include: stiffness, arched back, stilted gait, paralysis and heart failure. Losses in some herds have been quite high. Subsequent performance of an animal which "recovers" from this disease might, perhaps, be lower than that of a normal animal. The disease may be treated by injections of a selenium-vitamin E preparation. Some veterinarians are presently prescribing the use of a sodium selenite-vitamin premix which is fed to the pregnant cows via the salt. Many producers in the Innisfail, Rocky Mountain House and Sundre areas are now using this method which, it appears, eliminates or minimizes the problems. Only veterinarians can add selenium to a ration; any such addition by veterinarians must be on a prescription basis

Ullrey (16) stated that during the period 1967-1970 vitamin E-selenium deficiencies were diagnosed in 37 Michigan swine herds. In many cases weanling pigs died suddenly. The rations fed were low in selenium and vitamin E (alpha-tocopherol). Environmental stress seemed to precipitate deficiency problems which otherwise might not have occurred. Symptoms of the deficiencies included paleness of the skeletal muscles and necrosis of the liver. "Mulberry heart disease" has caused some losses in Alberta. This disease, which usually affects rapidly growing pigs which are two to four months of age, has been linked to a selenium-tocopherol (vitamin E) deficiency.

CAN AN ANIMAL CONSUME TOO MUCH SELENIUM?

Yes! In some areas in which the soil contains high levels of selenium certain plants (e.g. *Astragalus sp.*) accumulate selenium. Under conditions of drought or overgrazing animals may consume large quantities of these "accumulator" plants and, thus, may ingest toxic levels of selenium (12,17). Symptoms of selenium toxicity include loss of condition, loss of appetite, sloughing of hooves, arched back and eventual death. The Medicine Hat - Manyberries area contains some high selenium soils. Instances of apparent selenium toxicity have been reported in this area. Animals on pasture which is not overgrazed will probably not consume much Astragalus. Animals on poor pasture may, however, consume significant amounts of these accumulator plants.

The resulting toxicity might, perhaps, be complicated or

worsened by concomitant deficiencies of protein and phosphorus. Selenium levels as low as 5 ppm (5000 ppb) have been implicated as "toxic" but only where feeds containing such levels are consumed over long periods of time (several weeks or months). Herbage levels of up to 5000 ppm have been reported in seleniferous areas. Some recent work (14) has indicated that combinations of methionine and vitamin A might be used in a ration to combat selenium poisoning.

In Alberta documented cases of selenium poisoning are relatively rare. It would appear that it is a minor problem compared to that of selenium deficiency.

DO HUMANS SUFFER FROM SELENIUM DEFICIENCY?

No one knows. It is likely, however, that adults do not suffer from a deficiency due to the variety of foods from various areas that are consumed. One wonders, of course, whether muscular dystrophy in humans is related to selenium or vitamin E intake. Hidiroglou (6) states that the human disease is not nutritional but is inherited. D.F.L. Money discussed a rather alarming possibility in a recent paper (10). He stated that the "Sudden Deaths In Infants Syndrome" ("Crib Death") may be caused by a deficiency of selenium or vitamin E. Cow's milk contains considerably less selenium and vitamin E than human milk.

Hopefully, the medical profession will examine the possible implications of low levels of selenium and vitamin E in human nutrition.

SHOULD SELENIUM BE ADDED TO ANIMAL RATIONS?

The provision of dietary selenite appears to be the most logical method of preventing white muscle disease. Selenium can be provided through the use of wheat from soils high in selenium or linseed meal. It is difficult to predict, however, which grains may be high in selenium. Furthermore, the routine use of concentrates does not fit the pattern of feeding normally used by Alberta producers. Providing selenite in the salt would be the most direct and inexpensive method of routine administration of this mineral. The use of selenium in feeds is, however, prohibited by federal Plant Products Division regulations (as mentioned earlier veterinarians can provide it on a prescription basis). The reason for this ban on selenium is that it is allegedly carcinogenic. In a very excellent article in "Feedstuffs" (5) Dr. D.V. Frost makes a very good case for the inclusion of selenium in prepared feeds. He refutes the "carcinogenic stigma" and, in fact, suggests that the human population in North America does not consume enough selenium to meet requirements for "optimum health".

It would appear that selenium may be cleared in Canada and the U.S.A. as a feed additive for monogastric rations but not for ruminant rations. Perhaps further Alberta work will provide evidence which will be favorable to the addition of this mineral to ruminant rations as well.

Prepared By:

D. L. Massey, Plant Physiologist
P. J. Martin, Animal Nutritionist

Soil and Feed Testing Laboratory
Alberta Department of Agriculture

REFERENCES

1. ARTHUR, D. 1971. Selenium content of some feed ingredients available in Canada. Can. J. Anim. Sci. 51: 71-74.
2. BEESON, W. M. 1970. Nebraska Feed and Nutrition Conference (quoted in Feedstuffs, Mar. 21, 1970).
3. CARTER, D. L., BROWN, M. J., ALLAWAY, W. H. and CARY, E. E. 1968. Selenium content of forage and hay crops in the Pacific Northwest. Agron, Jour. 60: 532-534.
4. DAVIES, E. G. and WATKINSON, J. H. 1966. Uptake of native and applied selenium by pasture species. N. J. Agric. Res. 9: 317-327.
5. FROST, D. V. The Case for Selenite as a Feed Additive. Feedstuffs, July 31, 1971.
6. HIDIROGLOU, M. and LESSARD, J. R. Nutritional Muscular Dystrophy-White Muscle Disease. Cattlemen, September 1969, p. 34.
7. JORDAN, R. M. 1970. Selenium-vitamin E interrelationship in preventing nutritional muscular dystrophy in lambs and calves. Thirty-First Annual Minnesota Nutrition Conference.
8. KUBOTA, J. ALLAWAY, W. H., CARTER, D. L. CARY, E. E. and LOZAR, V.A. 1967. Selenium in crops in the United States in relation to selenium-response diseases of animals. J. Agric. Food Chem. 15: 448-453.
9. MASSEY, D. L. 1970. Uptake of selenium by forages. Alberta Soils Advisory Committee.
10. MONEY, D. F. L. Vitamin E and selenium deficiencies and their possible aetiological role in the sudden death in infants syndrome. 1970. New Zealand Medical Journal 71: 32-34.
11. MUTH, O. H. 1967. **Selenium in Biomedicine.** pp. 284-288.
12. OLSON, O. E. 1970. Selenium in feedstuffs: deficiencies and excesses. Thirty-First Annual Minnesota Nutrition Conference.
13. **Problem Feeds for Livestock and Poultry.** Pub. 1277. Canada Department of Agriculture. 1966.
14. Selenium poisoning shown inhibited by methionine, vitamin E. Sulphur Institute Journal. Vol. 7, Spring 1971.
15. **Stock-poisoning Plants of Western Canada.** Pub. 1361. Canada Department of Agriculture. 1968.
16. ULLREY, D. E. 1970. Selenium-vitamin E interrelationships in swine nutrition. Thirty-First Annual Minnesota Nutrition Conference.
17. UNDERWOOD, E. J. 1966. The Mineral Nutrition of Livestock. The Central Press (Aberdeen) Ltd.
18. WALKER, D. R. 1969 and 1970. Selenium content of forage crops in central Alberta. Alberta Soils Advisory Committee.
19. WALKER, O. J, HARRIS, W. E. and ROSSIE, M. 1941. Selenium in soil, grains and plants in Alberta. Can. J. Res. 19: 173-178.

GOVERNMENT OF THE PROVINCE OF ALBERTA

DEPARTMENT OF HEALTH

Environmental Health Services Division

Room 303, Administration Bldg.,
EDMONTON 6, Alberta.

March 11, 1969.

Mr. F. J. Dawley,
Municipal Secretary,

County of Mountain View No. 17,
DIDSBURY, Alberta.

Dear Mr. Dawley:

Re: Air Pollution - Harmattan-Elkton Area

On February 4, 1969 we forwarded to you a summary of the work which had been done and was being done to control air pollution in your area. At this time we would like to forward the following information to advise you of developments since the first of February.

One of our mobile air pollution units was moved into the area on February 7th. The first location was at the Stockburger ranch about 4 miles due north of the plant. It remained there for about two weeks and was then moved to the farm of Mr. E. H. Braun, about 3 miles northeast of the gas processing plant. This unit contains equipment which continuously samples and analyzes the air for sulfur dioxide and, by mean of a separate instrument, a continuous sample is taken to measure the presence of hydrogen sulfide and to a lesser extent, measures the mercaptan content of the air. In addition, the unit houses equipment to measure wind speed and direction, air temperature, humidity and barometric pressure. The operator of the unit maintains all of this equipment and tabulates the data obtained so that a summary report can be prepared at the conclusion of the survey. Also, the operator is available to check out reports of odors noted in the area and he makes at least a daily tour of the area for the purpose of locating any sources of significant odors.

As mentioned in our previous letter, reports of adverse conditions would be checked out quickly and we have received a few reports and have checked

them out as quickly as possible. Reports of strong odors are the most frequent, however, we did have one report of suspected adverse effect on pigs at one farm and this report was checked out the same evening that it was received, in fact within an hour of the time the report was received.

In addition to the above noted work a meeting was held with representatives of the Company operating the plant and the associated wells in Edmonton on February 20th. At this meeting we reviewed the complaints which had been registered with us and the possible sources of air contaminants which might have caused the complaints. Particular attention was given to the operation of the gas wells, the flare system at the plant and the burn pit used for treating and disposal of liquid wastes at the plant. I might add that this meeting was attended by representatives of the Oil and Gas Conservation Board and the Veterinary Services Branch of the Department of Agriculture as well as the representatives from the Company and the Department of Health.

Our current plans are to maintain the mobile unit in the area for at least another two weeks and to review the information we have gained up to that time. If the findings are that the conditions causing concern are at a satisfactory level, then the mobile unit will be moved on to other areas and the program of report investigation would be maintained. In the interim period we would be glad to receive from you any reports of conditions which you feel require investigation and also any comments which you may wish to make on the conditions which are currently being experienced in the area.

Yours very truly,

H L Hogge

H. L. Hogge, P. Eng., Director,
Environmental Health Services Division.

HLH:ad

c.c. - Honourable J. Donovan Ross
- Honourable R. C. Clark
- Dr. P. B. Rose
- Oil and Gas Conservation Board

GOVERNMENT OF THE PROVINCE OF ALBERTA

Department of Health
Environmental Health Services Division

Administration Building,
EDMONTON 6, Alberta.

March 31, 1969.

County of Mountain View No. 17,
DIDSBURY, Alberta.

Dear Sir:

Re: Air Pollution: Harmattan-Elkton Area.

Further to our letters of February 4 and March 11, 1969, concerning the above subject, the following developments have taken place since the March 11 letter:

On March 13, 1969, our mobile air monitoring unit was moved to the L. McLeod residence which is located in the Little Red Deer River Valley approximately two miles north northwest of the subject plant. The same equipment as used in the Stockburger and Braun surveys was in operation and once again the odor surveys were conducted on a daily basis. The results of the odor surveys which were conducted by the operators of the mobile monitoring unit indicate that there are intermittent odors in the vicinity of the plant but they are generally not of such a degree as to cause concern.

One odor complaint was registered with the mobile unit operator but unfortunately he was advised of the condition after the odor had subsided. Consequently the operator was unable to conduct an investigation as to source and cause.

On the subject of odors and other conditions in the area, as was pointed out in our letter of March 11, 1969 we would welcome your comments on these subjects.

. . .

As the monitored SO_2 and H_2S levels in this survey as in the previous surveys conducted at the forementioned residences during February and March of 1969 indicate that the level of sulfur gases are not excessive, the mobile unit will be relocated in another area during the week of March 31, 1969.

The firm operating the subject plant has advised this office that they are studying ways of means of altering their field operations in such a manner as to eliminate the need for flaring the Harmattan Leduc wells. As the practice has not been proven, various tests are being run to test the feasibility of such an operation. This office has also been advised that the company is planning to dispose of the plant effluent water via a deep well injection system. It is felt that both proposals are significant.

If any strong odors or other air pollution affects are noted in the future, we would ask that the proper authorities as pointed out in our letter of February 4, 1969 be advised immediately. It is much easier to act on a complaint during or immediately following the time of the complained of condition than at some time later.

In summary, this Department is doing its utmost to ensure that your environment is a safe one and all of the data gathered indicates that it is.

Yours very truly,

Pat B Rose

P. B. Rose, M.D.,
Deputy Minister of Health.

JCL:od

c.c. -Honourable J. D. Ross
-Honourable R. C. Clark
-Dr. P. B. Rose
-Oil & Gas Conservation Board

CARSTAIRS VETERINARY CLINIC

DR. H. SUTMOLLER
& ASSOCIATES

BOX NO. 60
CARSTAIRS, ALBERTA

PHONE 337-3221

Mr. C. Lockwood,

Calgary, Alta.

Dear Sir,

I am writing you in a hurry, because I want to get this letter out to you today, although I have very little information. What I have does not look promising. The problem is basically like this: the grey wooded soil west of highway 2 is low or deficient in selenium,a trace mineral necessary for proper muscle formation. There are two theories how sulphur will affect selenium.

1. sulphur interferes with the plant metabolism and prevents it from taking up selenium, there fore the cattle do not get enough.

2. sulphur is in itself deficient in the soil and increased levels of sulphur will stimulate growth and production of plants, therefore the amount of selenium in the plant becomes proportionally less, a dilution effect, thus the cattle get less selenium than before.

The problem is that sulphur in itself may be beneficial and all tests and research sofar supports the last theory. The selenium deficiency is brought on by increased production, not necessarily by any action from the sulphur.

This is the information I have been able to collect and I am afraid that it is not going to help the case against sulphur discharge at all, if anything it may be used against my appeal. There are too many unknowns, e.g., how much sulphur was there in the soil before the gas-plants became operational, how much will actually come back to earth, what is a beneficial level and what is too high. This whole problem is too complicated to be able to research it properly and a lot of data

CARSTAIRS VETERINARY CLINIC

DR. H. SUTMOLLER
& ASSOCIATES

BOX NO. 60
CARSTAIRS, ALBERTA

PHONE 337-3221

would have to be turned up, which I do not have access to. I am still collecting information from different sources, but this will not be available right away. I don't know if vague generalities are going to help your case very much, all I can say is that the uninhibited discharge of chemicals such as sulphur may have a severe and possibly irreversible effect on plant and livestock. There are too many unanswered questions which we at the local level are unable to answer, but need to be researched properly by scientific workers.

I have no time to go over this again, so excuse the typing and spelling mistakes. Copy to Mr. Bagnall. Phone me any time if you like to discuss this.

Hugo Sutmoller

ALBERTA DEPARTMENT OF AGRICULTURE

PLANT INDUSTRY DIVISION

Our File: 407.

Agriculture Building
9718-107th Street
Edmonton K Alberta
T5K 2C8.

October 30, 1972.

Mr. W.J. Bagnall, Reeve,
County of Mountain View,
Didsbury, Alberta.

Dear Mr. Bagnall:

This letter is further to our discussion with you in your office on October 27, 1972.

I would like to encourage you again to forward your county's presentation made to the Energy Resources Conservation Board hearings last spring to the Environment Conservation Authority in Edmonton. The Authority wishes to have as many submissions as possible and I am sure would accept your written submission following the public hearings which concluded in mid-October.

Yours truly,

A W Goettel

A.W. Goettel,
Head, Soils Branch.

AWG/lo.

c.c. N.O. Wohlberg, D.A. Olds.

A. S. Edmond B E N Z
13027-121 Str./ 454 - 0284
E D M O N T O N .

Edmonton, the 8. november 1972

Mr. Dr. Walter T r o s t
Chairman of the Environment Conservation Authority
E D M O N T O N

Dear Sir,

May I ask you to accept my submission, as a contribution into the environmental impact of sulfur.
When I came to Edmonton in november 1966, I had a new natural gas stove and boiler (Caleman) installed by Northwestern Utilities. Wherever I was before, I had central-heating. It was the first time that I came in contact with natural gas supplying my home - appliances. I have not been happy with this kind of combustible which bothered me for its high sulfur content. Year by Year, I was fearing the coming winter-heating periods, more and more. To improve the deficient heat-regulating system on my stove, I ordered sept. the 23. 1972, a thermostat, which was then later in the evening of the 10. october 1972, installed and sealed-of. That same night, I woke up with disconfort, showing strong signs of sulfur poisoning, in a manner I never had experienced in the last six years. " There was no odor at all " , each time the thermostat put the stove in function, the symptoms became worse. Through my profession I am familiar with Sulfur - poisoning symptoms, so I called at 5.30 a.m. the City Police about the high Sulfur level in the gas-mains. They told me to call Northwestern Utilities, what I did. Shortly after an employee of this company checked my stove and found a small leak in the newly installed thermostat, - emitting sour gas from the pipe - .
I was wondering about how many thousand Edmontonians, adult and children are experimenting daily such Sulfur Symptoms, and not

knowing it's source. May it be from leaking sour gas or from sulfur dioxide through atmospheric pressure obstructing the stack-emission on their house etc. Between installation of the thermostat and it's repair, four men from the Northwestern Utilities were at my house. Two of them showed signs of sulfur - poisoning and yet these men are most time on the road, travelling from one point to the other and are relatively very short time exposed to these gas compounds.
On october the 19. 1972, I participated at the hearing into the Environmental impact of Sulfur, in Edmonton.
Obviously, I was expecting to hear at this meeting interesting facts and concret sub-lethal symptoms of ill-health thad had occured to adults,children and animals, living close to processing plants; But these informations were inaccurate for to diagnose.
I also noticed the " absenteeism " of the medical professions at these hearings ! Strange, when compared with their support to ban the sale of fire-crackers, - one of the minor nuisances - .
It must be taken in account, that both, the Petroleum -, Natural Gas industries and the Canadian medical Associations are either controlled or influenced by U.S. interest.

My concern lay's not so much in the lethal dose of sulfur compounds, which is a matter of processing at the plant; legislations that enforce standard for the workers health and safety, effective monitoring system, inspection, public control, medical attention etc. to avoid deaths and accidents at the sulfur - extraction plants.

Of high concern is the sulfur + compounds poisoning between the " Zero and lethal level " that has an impact on all living cells. Longtime exposure to these low sulfur, selenium and other compounds leads to a long list of chronical disease conditions, ranging from mental disturbance to sexual impotence. They also prepare the soil for cancer, specially in women, for its relation to the skin, abdomen, disturbed oxidation,assimilation and blood - congestions. " Pre - Cancer conditions " that are neither diagnosed nor treated by today's standard of the medical profession.

The rising production and consumption of sulfur and sulfur-compounds during the last two hundred years, from a few thousand tons at the beginning of the 18 th. century, up to more than 30 million tons annually for numberless technical, industrial processes, as for insecticides, pesticides, fertilizers,matches,paints, sulfa-drugs, food preservers, for fumigating food,wines etc. to bleach food for its embellishment etc. has reached an oumost alarming stage, that requires public intervention and control over the " Devil's - Kitchen " called Chemistry. In addition, we are plagued with air -, water -, and soil - pollution from Sulfur - extraction plants as well from Aluminium plants. Through stack-emission discharging hundred thousands of tons annually of lethal Sulfur-dust, Sulfur oxide, Sulfuric acid, Selenium etc. over grain fields, pasture land, forests and lakes, at all stages of plant-growth and season of the year, of which man and all other living creatures have to live, - from which biological harmony alone, depend our physical and mental well-being !
(The American production of sulfuric acid exeeded 28,000,000 tons annually in late 1960, a figure corresponding to a daily production of 3/4 lb. per person throughout the year. A potential poison, a few mgr. of sulfuric acid inhaled or entering the bloodstream leads to blood-decomposition and death)

Sulfur damages on human health had already made head-lines in the early years of the 18 th. Century. It started with the warning by Dr. Samuel Hahnemann (1755-1843) the Founder of the Homeopathy, he discovered the " law of similar " stating that a disease can be cured by those drugs, that produce symptoms of the same disease in a healthy person. On this base, his research into symptoms and effects of minerals + compounds upon humans, in sub-lethal dosages, had brought forth the most perfect exposition of the physical and mental symptoms of these substances. Between these tested, were also: Sulfur (S), Acidum sulfuricum (H_2SO_4), Sulfur jodatum (S_2J_2) Selenium (Tellerium), Mercurius sublimatus corrosivus, - sulfuricus, Plumbum, metallicum, aceticum, Cuprum etc.

His Theory had been acknowledged throughout the World, except by

the universities who lost more than fifty percent of their patient to the Homeopathic Doctors.
The 18 th century had marked the destiny of humanity, in her losing battle for health with the Dogma of the Universities.
It had started with the restless hunt for bacteria and virus, with the Smallpox and other Immunization swindle, the Governments murdering and crippling our children. The Pill-Health-universities, hostile against theories and therapies that proven success in the prevention or cure of diseases that plagued society from T.B. diabetes,arthritis to mental disturbance, Polio, MS, cancer and diseases resulting in the course of employment.

The submission presented at the hearings told about : precise laboratory tests-, vegetation tolerance limits-, ambient standards-, emission standards-, Maximum acceptable levels-, Maximum desirable levels-, limits of allowable concentrations-, in precise ppm, etc.

These are nice words, supported with References, Tests and Research claims, to assure the Government and public of the harmlessness of sulfur when kept at the " desirable ", acceptable " and " Maximum Tolerable level, in ppm " for each mayor air- soil -, and water-pollutant. As long-term, continious exposure of guinea pigs, dogs and plants had shown !

" But there is one big problem " and that is : that human-, animal life and vegetation does not follow textbook - rules .

The major air - pollution disasters had shown, that they had happened in these so called " desirable or tolorable, sub-lethal levels " and deaths were the exception.

It is a Capital Error, to relate the sulfur - compounds pollutants to damages to the lungs or irritant damages to the eyes " only " when these both symptoms are only a small part of the whole sulfur-symptoms complex, which is bound to mental and physical disturbances in human's and animals. Animal tests are a myth in lethal and sub-lethal experimentations. They cannot communicate the sensations they feel during the experiments and afterwards.

In comparision to the research results and references presented in the mentioned submissions, it can be said, that hundred fifty years of experiences in treating sulfur - disorders, that there is no safe sulfur level, may it be by inhalation or orally.

" Air -, Soil -, Water -, Food - Sulfur Pollution does not mix with Farming, Livestock, (animal live) Agriculture and Vegetation, nor with public Health ".

Our Ancestors got their Vitality, their Health and Stamina from the daily Oatmeal dishs they had eaten.
Since many years I had included one or two Oatmeal dishs in my daily diet. But, unfortunately I had to give it up, when I came to Canada. And this only after I had made three unsuccessful attempt to stick with my Oatmeal. It was not because it did not give me nutritional satisfaction ! The Problem was, that short after each new start I experimented molesting symptoms of sulfuric acid and selenium poisoning with an acid body-odor.
(The same symptoms will be found in animals feed with surplus - oat)
Indeed, we also eat meat from sick animals, food-,air-,water-, and Drug - polluted !

A set-back, in Canadas exportations of agricultural products is imminent. Even the high respect and excellent image Prime Minister Trudeau enjoy abroad, will not suffice to sell polluted stuff.

Edmund Franz

intercomp
RESOURCE DEVELOPMENT AND ENGINEERING LTD.
639 - 5th AVENUE S.W., CALGARY, ALBERTA T2P OM9, CANADA, (403) 264-7205

November 13, 1972

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107th Street
Edmonton, Alberta T5K 1G5

Attention: Dr. Trost

Dear Dr. Trost:

During the recent hearings conducted by ECA in Calgary in relation to the environmental effects of the operation of sulphur extraction gas plants, Mr. Flook expressed some concern as to the coverage provided by a given number of monitor stations around a gas plant. It was indicated that the number of monitor stations may have to be as high as fifty or a hundred for an adequate coverage.

We submit that one of the primary uses of the state of art dispersion modelling is to provide the pollutant concentration <u>everywhere</u> in an air quality region, even for complex meteorological and terrain conditions. The predictions from such a numerical model can be easily calibrated using the measurements from a few strategically located monitor stations. Thus, if the measurements from only a few appropriate monitor stations are used in conjunction with a numerical model, the pollutant concentration everywhere, at all times, can be found. To achieve such resolution without the aid of a numerical model may require a large number of monitor stations, as suggested by Mr. Flook. The cost of using a numerical model with some monitor stations is substantially lower than that of operating a large number of monitor stations. This will also provide adequate control of the air quality in the regions where the location and maintenance of monitoring devices may be very expensive or physically impossible due to terrain considerations.

Yours truly,

R. K. Agrawal

R. K. Agrawal, P. Eng.

RKA/sgb

November 30,1972
Box 159
Sylvan Lake, Alberta

Environment Conservation Authority
9912 - 107 St.
Edmonton, Alberta

Dear Sirs:

I'm concerned about sulphur emission for two reasons.

First I notice that the haze or smog is getting worse in this area to the extent that I've made two complaints to the Environment Branch requesting a monitoring truck to check the sulphur dioxide content in the air.

Secondly sulphur dioxide definitely affects my health and possibly many other people who are not aware that sulphur dioxide may be the cause of respiratory, nasal and sinus problems. This gives me trouble here in the summer months and there does not seem to be any method of relief when the sulphur dioxide levels are high.

I attended the hearing in Red Deer and am amazed at the attitude of Oil Companies who say that controls should be left as they are. Some of these people should have been in Sylvan Lake the afternoon of October 11, 1972 to see how bad the smog can really get in this area.

I'm not familiar with gas plant operations, but could not the emissions from stacks be pumped back into the ground along with salt water etc. Also the same might be said for the many flare pits.

I hope that something can be done to prevent any futher polluting of our air.

Yours truly,

G.S. Didow

SULPHUR DIOXIDE AND FOREST VEGETATION

by

A. A. Loman, R. A. Blauel and D. Hocking

NORTHERN FOREST RESEARCH CENTRE

INFORMATION REPORT NOR-X-49

DECEMBER 1972

CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
5320 - 122 STREET
EDMONTON, ALBERTA, CANADA
T6H 3S5

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this report is to bring to the attention of agencies concerned with atmospheric pollution control as well as gas industries, the effects of sulfur dioxide on forests. Particular emphasis is placed on the role of sulfur in green plants and also on the very close interdependence of plant metabolism, sulfur assimilation and sulfur dioxide tolerance levels. The fluctuations of foliar sulfur content in healthy vegetation are described in light of frequent use, by research workers, of foliar sulfur content as a damage index parameter. An attempt is made to clearly distinguish between controllable and uncontrollable factors that cause sulfur dioxide damage in forest vegetation.

2. SULFUR REQUIREMENTS IN PLANTS

Sulfur is an essential element in plant metabolism, and in many structural components of plants. Sulfur is usually absorbed by the roots as sulfate ion, but may also enter the leaves as gaseous sulfur dioxide, or dissolved in water as sulfurous acid (Syratt, W.J. et al 1968). Most sulfur atoms undergo valency changes from +6 to -2 prior to incorporation into organic form in a process called "assimilatory reduction". However, many active organic sulfur compounds are found in the +6 valency state, as sulfate. In the reduced state of -2, sulfur is an important constituent of all proteins, structural as well as metabolic, as part of the molecular structure of the amino acids cystein, cystine and methionine. For protein synthesis alone, sulfur is required in rather large amounts. Sulfur is found in the vitamins thiamin and biotin. It is also the major element in the backbone of ferredoxin, a sulfur-iron-protein complex which functions in the electron transfer system in photosynthetic reactions, and in nitrate and nitrate reduction (Mahler and Cordes 1966).

Green plants possess complex enzyme systems to reduce and assimilate both atmospheric sulfur dioxide and sulfate ion in aqueous solution. In healthy leaves sulfur contents should range from 500 - 14,000 ppm by dry weight (0.5 - 14 mg per gm of dry weight) depending on species (Treshow 1970). Concentrations below 250 ppm are considered critical, and give rise to deficiency symptoms, and to the substitution of selenium for sulfur in sulfur aminoacid and protein synthesis (Treshow 1970).

3. THE INFLUENCE OF FACTORS OF THE ENVIRONMENT ON PLANT METABOLISM, ON SULFUR DIOXIDE ASSIMILATION AND ON SULFUR DIOXIDE TOLERANCE LEVELS

Sulfur dioxide is readily assimilated by green plants, provided a threshold rate of gas application is not exceeded. This threshold rate is not a fixed value, but depends on fluctuating sulfur dioxide tolerance levels of plants. Any combination of at least twelve environmental factors induces fluctuations in sulfur dioxide tolerance levels. These same environmental factors induce fluctuations in rates of plant metabolism and sulfur assimilation (Linzon 1971). In general, there exists an inverse relationship between the rate of plant metabolism and sulfur dioxide tolerance levels, whereas fluctuations in rate of plant metabolism and sulfur assimilation are in phase in the presence of atmospheric sulfur dioxide. In other words, conditions that favour good plant growth, increase the capacity of the plant to assimilate sulfur dioxide, but reduce the plant's tolerance to this gas.

None of the environmental factors that influence sulfur dioxide tolerance levels can be controlled in unmanaged forests. Sulfur dioxide tolerance levels are low under the following conditions:

1. high light intensity both before and during fumigation. (Davies 1969, Rohmeder *et al* 1965)

2. high temperature (Daines 1969)
3. daylight (Daines 1969)
4. growing season (Daines 1969)
5. high relative humidity (Syratt _et al_ 1968, Thomas _et al_ 1956, Daines 1969).
6. water on leaves (Costonis 1971)
7. high soil moisture (Daines 1969)
8. old plants (Daines 1969)
9. low vigour due to insects or diseases
10. low nutrition levels (Faller _et al_ 1970, Enderlein _et al_ 1967)
11. susceptible species (Scheffer _et al_ 1955, Dreisinger _et al_ 1970)
12. genetic factors within species (Boertitz 1964, Boertitz _et al_ 1969, Dochinger, 1968)

Several workers developed mathematical formulae to calculate threshold rates in terms of gas concentrations and durations of exposure to symptom development. Their assumptions were that all the above environmental factors were constant.

4. SYMPTOMATOLOGY OF SULFUR DIOXIDE INJURY

Fumigation of trees with sulfur dioxide, generally induces typical changes which results in altered leaf function, colour and form. These may, over several days or weeks, result in changes in growth and development. Together, these changes constitute a complex of symptoms, and their study is termed symptomatology.

A great variety of factors can affect the rate and extent of symptom expression and many factors may independently produce some of these symptoms, making positive diagnosis complex and dependent on wide knowledge. Furthermore

under some conditions, changes may take place that in themselves are not damaging, but predispose the tree to damage from other causes occurring either simultaneously or subsequently.

(a) Gross visible effects

As sulfur dioxide enters the needles of conifers or the leaves of broad leaved trees, it dissolves in water and forms sulfurous acid. As described earlier, if the rate of entry is very low, the sulfur can be metabolized in a normal way and no symptoms develop. If sulfur in excess of the tree's requirements enters slowly, it eventually causes a slowly-developing (chronic)* injury, characterized visibly by a general chlorotic (yellow) appearance.

If, however, sulfur dioxide enters too rapidly, the tree's systems for coping with sulfur are overwhelmed and acute damage occurs. Affected leaves first appear water-soaked and straw coloured, the symptoms generally beginning at the tips of needles of conifers or the margin of broad leaved trees. In conifer needles, symptoms proceed towards the point of attachment, whereas in broad leaved trees, the intercostal leaf areas are affected shortly after the marginal areas. The affected areas soon dry out and gradually become reddish brown and brittle (necrotic or dead). Commonly, symptoms are more severe on the side of the tree facing towards the emission source.

Repeated fumigations may injure previously unaffected portions of partially damaged needles, resulting in a banded appearance of the necrotic portions. Severe fumigation will also affect the veinal areas of leaves of broad leaved trees. Trees are killed by severe fumigations when not only

---

*chronic and acute relate to the morbidity status of the tree and not to disease stages.

the leaves but also next year's buds are killed.

The gradual appearance of chronic symptoms as a result of continuous, low-level exposure, may be parallelled by intermittent sub-acute fumigations of shorter duration. Both of these have the effect of shortening needle life and needle retention, although not as markedly as acute fumigations. Unaffected needles are normally retained for three to five years. In areas of continuing fumigation, retention is reduced to one to two years (Boertitz 1964, Boertitz 1969). This reduces tree growth and results in diminished terminal growth, shorter twigs and internodes, smaller needles, and in narrower growth rings; these can act as aids for diagnosis and measurement of injury.

Sub-acute fumigations, during the period of needle expansion, may similarly retard growth of that year's needles. The result is that twigs bear needles of variable lengths. This is called the "big-little needle" symptom, and is quite common in areas subjected to sulfur dioxide emissions.

In broad leaved trees, chronic injury results in chlorosis of leaf tissues in small flecks, mottled, or diffuse, and finally in a general yellowing of the entire leaf (Dochinger 1971).

(b) Microscopic effects

Damaged needles commonly show dead or necrotic brown zones, a transition zone of yellowish to reddish colour, and a zone of green, apparently unaffected tissue. Sulfur dioxide does not produce "hidden damage" in green plant tissue (Katz 1949). However, internal tissue changes that have diagnostic value are evident in the transition zones of affected needles. Changes occur in the undifferentiated parenchyma cells as a result of fumigation with sulfur dioxide (C.C. Gordon, personal communication).

(c) Physiological effects

Sulfur dioxide fumigations have temporary effects on the relative concentrations of intermediary metabolites including non-sulfur containing compounds. As was mentioned earlier, however, there is to date no evidence of hidden sulfur dioxide damage in green tissue. The development of visible symptoms such as the yellowing of foliage, is associated with the breakdown of chlorophyll molecules and accessory pigments such as carotene and xanthophylls. (Mamaev *et al* 1969).

5. FOLIAR SULFUR CONTENT AS A DAMAGE INDEX PARAMETER

Foliar sulfur levels fluctuate in healthy leaves. Katz (1949) stated: "Unless the concentration and exposure to gas and other (environmental) factors are known accurately, there is no quantitative relation between the increase in sulfur levels of plant tissue and the degree of injury, because the sulfur content is subject to great variation in normal plants". Many workers in the 60's and 70's confirmed Katz's conclusions, that foliar sulfur levels are not related to damage by sulfur dioxide. Some of these are Berry, G.R. *et al* 1964, Viel, M.G. *et al* 1965, Garber, K. 1960, Wentzel, K.F. 1968 and Bjorkman, E. 1970. Guderian 1970 (b) found that sulfur levels continue to fluctuate in the green photosynthesizing tissue of partially killed needles, whereas sulfur levels remain steady in the killed portions of such needles. Guderian further reported that foliar sulfur levels decrease after cessation of fumigations, and are therefore not only dependent on rates of sulfur assimilation during fumigations, but also on frequency and duration of sulfur dioxide free periods between fumigations. Hence the timing of sampling for sulfur level determinations after exposure to sulfur dioxide becomes an additional variable factor. There is another

complicating factor. Long periods of uninterrupted exposure to very low levels of sulfur dioxide cause greater increases in foliar sulfur levels than shorter periods of exposure to higher but still sublethal levels of sulfur dioxide (Guderian 1970 (a).

It is clear that foliar sulfur contents cannot be used as a measure of damage by sulfur dioxide. However, given a steady source of sulfur dioxide emissions, as found in sour gas plants, foliar sulfur levels will be indicative of the extent of sulfur dioxide dispersion. Katz (1949) noted: "Nevertheless, such data (foliar sulfur contents) from comprehensive collections of certain sensitive plants, may be used to define the area within which the gas occurs". Today, this is indeed the only "practical" use that can be made of knowledge of foliar sulfur contents obtained from field samples.

Results of a co-operative study of the Alberta Forest Service and the Provincial Air Pollution Control Division showed that pine and spruce foliar sulfur contents fluctuated upwards in the vicinity of sour gas plants for three to five years, after which they fluctuated down again to levels found at the time the gas plants went into production, whereas foliar sulfur contents of aspen and poplar continued to fluctuate upwards (Ullman 1967). From a biological point of view, the fluctuations in foliar sulfur levels in pine and spruce after three to five years exposure to sulfur dioxide may be ascirbed to any of the uncontrollable factors of the environment which were listed above and about which we have no information. From a practical point of view, sulfur dioxide emissions near the sour gas plants investigated by these agencies have up to now obviously been below the tolerance level for the main tree species.

6. SULFUR DIOXIDE AT THE STACK AND IN THE ENVIRONMENT

(a) Controllable factors

The amount of sulfur dioxide released into the environment depends on the following factors that can be controlled:

i) The efficiency and reliability of installed pollution abatement equipment

Control of pollution at the source by means of the "Best Practicable Technology" approach, is the strategy recommended by Federal Authorities (Lucas, 1971). Operating limitations of sulfur recovery units in gas plants result in 0.5 - 1 per cent below theoretical recovery rate after initial start up, and will decline further to 1.5 per cent before the catalyst is replaced because of catalyst deactivation (Klemm, 1972).

ii) The rate of production

Once the sulfur recovery efficiency of an individual gas plant is known, the rate of production is the principal controllable factor determining rates of sulfur dioxide emission from the stack.

iii) Numbers of gas plants per unit area

Potential increases in numbers of gas plants depend on the discovery of new large fields. Amounts of sulfur dioxide releases into the environment can be controlled by limiting the numbers of gas plants with known production rates and sulfur recovery efficiencies, per unit area. (Tollefson, 1972). Extensive sulfur dioxide damage to forest vegetation has been associated with the mining

industry of the Sudbury region of Ontario. Sudbury is an example of too many sulfur dioxide effluent sources per unit area. There are 18 mines and 9 reduction plants, managed since 1888 by the International Nickel Company of Canada and the Falconbridge Nickel Mines. It is estimated that about two million tons of sulfur dioxide are emitted annually in the Sudbury area alone (Leblanc, Fabius et al 1972, Linzon, 1971 (a)).

iv) The rate of dispersion of stack effluent

The rate of dispersion of stack effluent cannot be controlled, but can be influenced by the proper selection of plant location and by effective stack height. Trail, British Columbia, is an example of the importance of topography on effluent dispersion. In Trail, Consolidated Mining and Smelting Company operates smelters that are situated in the Columbia Valley, which functions as an extended chimney. Stack effluents are not emitted randomly, but drift daily down the same areas. Reductions in growth rates were most pronounced in the vicinity of steady emission sources, but recovery to increased growth rates were noted in trees in the vicinity of reducing plants after the installation of pollution abatement equipment or plant closure (Katz 1939).

(b) Uncontrollable factors

i) Emergencies

Human error, mechanical failure or flaring during plant upset, may temporarily elevate sulfur dioxide concentration in the forest to above-threshold-levels. Since ground level concentration standards for flaring in Alberta (Anonymous 1970) are above the threshold level for jack pine, white spruce, trembling aspen, balsam poplar, white birch and larch, (Dreisinger et al 1970) (Table I), flaring during the growing season and in calm, humid and warm weather, may severely damage or kill well defined areas of forest vegetation. Possible synergistic effects of sulfur dioxide with other components of the effluent may be damaging.

ii) Weather conditions

Prolonged spells of severe cold may reduce sulfur recovery in gas plants by a significant amount of theoretical recovery rates and hence could constitute additional hazard.

Controlled rates of sulfur dioxide emissions at the stack are diluted in the atmosphere by the following uncontrollable and highly variable weather conditions.

i) windspeed

ii) wind direction

iii) temperature inversions

iv) relative humidity

v) precipitation

vi) mechanical and thermal air turbulence factors

Sulfur dioxide concentrations will therefore fluctuate from minimal, below-threshold-concentrations, to maximal, above-threshold-concentrations.

It is well established that plumes from stacks may retain their integrity for long distances during certain types of weather conditions. These plumes frequently impinge upon the ground surface at different distances from the stacks. Vegetation damage frequently results within these impingement areas which may encompass several square miles or more in area.

7. PROBLEMS ASSOCIATED WITH MONITORING OF ATMOSPHERIC SULFUR DIOXIDE

There are two basic problems in monitoring that must be understood:

1. In forests surrounding sulfur dioxide emission sources, sulfur dioxide concentrations will fluctuate constantly at any given point in the three dimensional space occupied by forests. In absolute terms, an atmospheric sulfur dioxide concentration is unique for a specific location, and for a specific, very short period of time. Hence data obtained from a monitoring station must be extrapolated with caution to locations outside the micro environment occupied by the monitoring device.
2. For the biologist, monitoring for atmospheric sulfur dioxide becomes meaningful when locations, concentrations and durations of lethal fumigations can be identified. Plants may be killed, either partly or completely when subjected to lethal concentrations of sulfur dioxide for short periods of time. Exposure cylinders will only provide information on cumulative amounts of

sulfur dioxide which can be averaged for numbers of hours or days of exposure, and are therefore of very limited use. Monitoring devices of the continuous monitoring type are essential for meaningful surveillance. These systems entail considerable cost, and must be placed in strategic positions which take into account differences in effluent concentration with height above ground as well as the principal plume impingement areas.

8. THE GREEN PLANT AS A MONITORING DEVICE FOR ATMOSPHERIC SULFUR DIOXIDE

Sour gas plants release known and controlled amounts of sulfur dioxide from the stack. Rates of effluent dispersion and sulfur dioxide effects on vegetation are determined by the cumulative effects of large numbers of interacting variables, none of which can be controlled. However, the green plant itself reflects the sum total effects of biotic and abiotic interacting variable factors of the environment. The green plant itself can therefore function as a monitoring device, and can serve as an indicator of the state of health of forests surrounding gas plants.

Plant species show a wide range of sensitivity to atmospheric sulfur dioxide. Among the most sensitive species are mosses and lichens (Leblanc 1971, Leblanc 1969, Gilbert 1968).

Short-term studies of short-term sulfur dioxide effect may be conducted by transplanting lichens into polluted zones, and recording the time required for the lichens to die. Results of such studies have shown that survival times near steady emission sources are minimal, but increase with increasing distances from such sources (Kirschbaum _et al_ 1971, Leblanc _et al_ 1966, Schoenbeck 1968).

Short-term studies of long-term sulfur dioxide effects involve the evaluation of lichen luxuriance and numbers of species in pre-selected sites. Modifications of this approach include the construction of an Index of Atmospheric Purity (Leblanc, Fabius et al 1972), the construction of detailed distribution maps of selected lichen species (Skye, Erik 1968), and the construction of a qualitative sulfur dioxide air pollution scale (Hawksworth, D.L. and F. Rose 1970). The results of these and other (Smith, C.W. 1968, Barkman, J.J. 1968, Gilbert, O.L. 1968) studies consistently showed that numbers of species decrease with decreasing distance to the emission source. A few anomalies were noted, where species of lichens were found in pockets inside areas otherwise denuded of these species. Such areas were believed to be sheltered from sulfur dioxide gas due to topography and surrounding vegetation which acted as buffer zones (Gilbert, O.L. 1970).

Meaningful biological monitoring systems can be developed when the specific functions and values of forests surrounding emission sources have been determined. Criteria of injury relating to a variety of resource use allocations have been summarized (Knabe 1971, Guderian et al 1960).

9. AMBIENT AIR QUALITY STANDARDS AND THE FOREST

In Alberta, the maximum acceptable ground level concentration standards for sulfur dioxide in forested areas are as follows: (Anon 1970)

(a) 0.30 ppm for 30 minutes

(b) 1.0 ppm for less than one hour for a short period of emergency flaring

The ambient air quality standards for Alberta in forested areas are as follows:

(a) 0.30 ppm for one hour

(b) 0.10 ppm for 24 hours

Dreisinger et al (1970 published minimum average concentrations of sulfur dioxide in ppm at which injury occurred (Table I).

Table I

Minimum average concentrations (in ppm) at which injury occurred (Adapted from Dreisinger et al 1970). Ground Level Concentration Standards (G.L.C.S.) and Ambient Air Quality Standards (A.A.Q.S.) (Anonymous 1970).

Species	30 min	< 1 hr	1 hr	2 hrs	4 hrs	8 hrs	24 hrs
			ppm				
Trembling aspen			0.42	0.39	0.26	0.13	
Jack Pine			0.52	0.44	0.29	0.20	
White birch			0.46	0.38	0.28	0.21	
Larch			0.41	0.38	0.34	0.26	
Balsam poplar			0.82	0.65	0.45	0.26	
White spruce			0.87	0.79	0.70	0.50	
G.L.C.S.	0.30	1.0					
A.A.Q.S.			0.30				0.10

A comparison of ground level concentration standards and threshold concentrations of sulfur dioxide for the species listed, all of which occur in Alberta, shows that 1.0 ppm for less than one hour, permitted during flaring, will injure Alberta forest species. All the other standards are below the threshold level of Alberta trees, but populations of the most sensitive plants, such as lichens and bryophytes will undoubtedly be killed. It has been

reported that the most sensitive species of lichens are unable to survive in areas where average annual sulfur dioxide levels are greater than 0.011 ppm, and no lichens survive in areas where annual concentrations of sulfur dioxide exceed 0.035 ppm (Gilbert 1968).

REFERENCES

Anonymous. 1970 Ambient Air Quality Standards. Province of Alberta. September, 1970.

Barkman, J.J. 1968. The influence of air pollution on bryophytes and lichens. Air Pollution Proceedings. First European Congress. Influence of Air Pollution on Plants and Animals, Wageningen, Netherlands.

Berry, Charles R. and George H. Hepting. 1964. Injury to eastern white pine by unidentified atmospheric constituents. Forest Sci., 10 (1):2-13.

Bjorkman, Erik. 1970. The effect of fertilization on sulfur dioxide damage to conifers in industrial and built-up areas. Stud. Forest Suec. 78.

Boertitz, S. 1964. Physiological and biochemical contributions to smoke damage research. Part I. Investigations into the individually different effects of SO_2 on assimilation, and on some substances of needles of spruce trees (Picea abies L. Karst.) by fumigation of some branches in an open area experiment. Rauchschadenforschung Tharandt, 4, (15).

Boertitz, S. 1969. Physiological and biochemical studies on smoke damage XI. Analysis of some needle constituents of spruce of different SO_2 resistance from a district with sulfur dioxide damage. Arch. Forstw. 18(2): 123-131.

Boertitz, S. and Vogl, M. 1969. Physiological and biochemical contributions to smoke damage research IX. Arch. Forstw. 18(1): 55-60.

Costonis, A.C. 1971. Effects of ambient sulfur dioxide and ozone on eastern white pine in a rural environment. Phytopathology 61: 717-720.

Daines, Robert H. 1969. Sulfur dioxide and plant response. American Petroleum Institute. New York Div. of Environmental Affairs 69:816 pp.

Dochinger, L.S. 1968. The impact of air pollution on eastern white pine: the chlorotic dwarf disease. J. Air Pollut. Contr. Assoc. 18:814-816.

Dochinger, L.S. 1971. The symptoms of Air Pollution injuries to broad leaved forest trees. In: Methods for the Identification and Evaluation of Air Pollutants Injurious to Forests. XV Congress of IUFRO. 1971.

Dreisinger, B.R. and P.C. McGovern. 1970. Monitoring atmospheric sulfur dioxide and correlating its effects on crops and forests in the Sudbury area. Proc. Impact of Air Pollution on Vegetation Conference, Toronto: Pp. 23.

Enderlein, H. and W. Kastner. 1967. What effect has nutrient deficiency on the resistance of 1-year-old conifers to SO_2? Arch. Forstw. 16:431-435.

Faller, N. 1968. Sulfur assimilation by ground plant material after sulfur-35 dioxide treatment. Z. Pflawzenernaer. Bodenk 121(2):111-116.

Garber, Kurt. 1960. Experience with leaf analysis in smoke damage tests. Angew. Botan. 34:33-37.

Gilbert, O.L. 1968. The effect of sulfur dioxide on lichens and bryophytes around Newcastle upon Tyne. Air Pollution Proceedings. First European Congress. Influence of Air Pollution on Plants and Animals. Wageningen, Netherlands.

Gilbert, O.L. 1970. Further studies on the effect of sulfur dioxide on lichens and bryophytes. New Phytologist 69(3):605-627.

Guderian, Robert, H. Van Haut, H. Stratmann. 1960. Problems of the recognition and evaluation of the effects of gaseous air impurities on vegetation. Z. Pflanzenkr. Pflanzenpathol. Pflanzenschutz. 67 (5)257-264.

Guderian, Robert. 1970 (a). The correlation between sulfur content in plants and sulfur dioxide content in the atmosphere. Z. Pflanzenkrankh. Pflanzenschutz. 77(4/5):200-220. April-May.

________, Robert. 1970 (b). Investigation of the quantitative relationship between sulfur and sulfur dioxide in the air. Part 2. Biurnal variation in sulfur near unaffected and gas-attacked plants. Z. Pflanzenkrankh. Pflanzenschutz. 77(6):289-308. June.

Hawksworth, D.L. and F. Rose. 1970. Qualitative scale for estimating sulfur dioxide air pollution in England and Wales using epiphytic lichens. Nature, Vol. 227:145-148.

Katz, M. 1939. In: Effect of sulfur dioxide on vegetation. National Research Council of Canada, No. 815. 447 pp.

Katz, Morris. 1949. Sulfur dioxide in the atmosphere and its relation to plant life. Ind. Eng. Chem. 41(11):2450-2465.

Kirschbaum, Ulrich et al. 1971. Flechten als Indikatoren für die Immissionsbelastung im Stadtgebiet von Frankfurt/M. Staub. 31(1):21-24.

Klemm, R.F. 1972. Environmental effects of the operation of sulfur extraction gas plants. Submitted to Environment Conservation Authority, September 1972.

Knabe, Wilhelm. 1971. Air quality criteria and their importance for forests. In: Proceedings of the XV Congress of IUFRO, Working Group "Fume damage" Sect. 24, pp 129-150.

Leblanc, Fabius and D.N. Rao. 1966. Reaction of several lichens and epiphytic mosses to sulfur dioxide in Sudbury, Ont. Bryologist, 69:338-346.

Leblanc, Fabius et al. 1972. The epiphytic vegetation of Populus balsamifera and its significance as an air pollution indicator in Sudbury, Ontario. Can. J. Bot. 50(3):519-528.

Linzon, S.N. 1971 (a). Economic effects of sulfur dioxide on forest growth. APCA Journal, 21(2):81-86.

Linzon, S.N. 1971 (b). Effect of sulfur oxides on vegetation. Presented at the November, 1971 Conference of the Pacific Northwest International Section of the Air Pollution Control Association, Calgary, Alberta.

Lucas, K.C. 1971. The federal role in air pollution control in Canada. Presented at the Pacific Northwest International Section Meeting of the Air Pollution Control Association, Calgary, Alberta.

Mahler, Henry R. and Eugene H. Cordes. 1966. Biological Chemistry. Harper and Row Publishers. New York, N.Y. 873 pp.

Mamaev, S.A. and Nikolaevskii, V.S. 1968. Harmful effect of sulfur dioxide on Scotch pine seedlings. Tr. Inst. Ehol. Rash. Ghivostn., Ural Filial, Ahad. Nauk SSSR. No. 62. 203-207.

Rohmeder, E. and A. von Schonborn. 1965. The influence of environment and heredity on the resistance of forest trees to the atmospheric impurities originating from industrial waste gases. Forstwiss. Zentr. 84:1-3.

Scheffer, T.C. and G.G. Hedgecock. 1955. Injury to northwestern forest trees by sulfur dioxide from smelters. U.S. Dept. Agric., For. Serv. Tech. Bull. 117, pp. 49.

Schoenbeck, Helfried. 1968. Einfluss von Luftverunreinigungen (SO_2) auf transplantierte Flechten. Naturwissenschaften, Berlin 55(9):451-452.

Skye, Erik. 1968. Lichens and air pollution. A study of cryptogamic epiphytes and environment in the Stockholm region. Acta Phytogeograph Suecica. 52. 138 pp.

Smith, C.W. 1968. Lichens as an indicator of air pollution. Preprint, Hawaii University, Honolulu. 6 p.

Syratt, W.J. and P.J. Wanstall. 1968. The effect of sulfur dioxide on epiphytic bryophytes. Council of Europe, Committee of Experts on Air Pollution. Air Pollution Proceedings. First European Congress. Influence of Air Pollution on Plants and Animals. Wageningen, Netherlands.

Thomas, M.D. and R.H. Hendricks. 1956. Effects of air pollution on plants. Pp. 1-44; Section 1. In: Magill, P.L., F.R. Holden, and C. Ackley (Eds.). Air Pollution Handbook. McGraw-Hill, N.Y.

Tollefson, E.L. 1972. Sources of air pollutants and future trends in air quality standards, CNGPA Second Quarterly Meeting, Edmonton, June 9, 1972.

Treshow, Michael. 1970. Environment and Plant Response. McGraw-Hill Book Company, New York, N.Y. 422 pp.

Ullman, P.M. 1967. Alberta Vegetation Summary. Alberta Dept. Health, Environmental Health Services Division. 36 pp.

Viel, M.G. and M.L. de Cormis. 1965. The effects of sulfur dioxide and of fluorine compounds on vegetation. Poll. Atmos. 7:381-391.

Wentzel, K.F. 1968. Sensitivity and differences in resistance of plants to pollution. Forst. Archiv. 39(9):189-194.

CRITIQUES

OCTOBER, 1972

ENVIRONMENT CONSERVATION
AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

SCIENCE ADVISORY COMMITTEE

CRITIQUE

NOT RECEIVED

AT TIME

OF PUBLICATION

FILE REPORT NOR-Y-73

R. A. Blauel (1973)

COMMENTS ON THE VEGETATIVE SECTION OF THE CANADIAN PETROLEUM ASSOCIATION'S SUBMISSION TO THE ENVIRONMENT CONSERVATION AUTHORITY, ALBERTA DEPARTMENT OF THE ENVIRONMENT, EDMONTON, ALBERTA.

Northern Forest Research Centre
Canadian Forestry Service
Environment Canada
Edmonton
Jan. 1973

INTRODUCTION

The Canadian Forestry Service was requested by the Environment Conservation Authority, Alberta Department of the Environment, to comment upon the contents of the vegetative section of a submission entitled "Environmental Effects of the Operation of Sulphur Extraction Gas Plants" and dated September 1972, and submitted to the Board by the Canadian Petroleum Association. The Canadian Forestry Service comment is contained herein.

COMMENTS

Readers of the Submission would have benefitted by some description of the modes of action by which sulphur dioxide injures plant tissues. To serve this purpose the following summarizes what is currently known.

Haselhof and Lindau (1903) reported that sulphur dioxide was bonded to aldehyde groups and that plant tissues were injured by the degradation of these compounds into sulphuric or sulphurous acid. Novak (1929) postulated that sulphur dioxide caused inactivation of iron in the chloroplasts which prevents the assimilation of organic compounds. Dorries (1932) stated that the interaction of acidic compounds resulting from sulphur dioxide split magnesium from the chlorophyll compound, changing it into a phenophytin and blocking the photosynthetic process. Thomas (1951) attributed the onset of acute injury symptoms to the excessive accumulation of either sulphite or sulphurous acid in plant tissues. Nikolavesky (1968) found that sulphur dioxide inactivated catalayse and increased both peroxidase and polyphenol-oxidase. Another report (Anonymous 1968) stated that hydrogen sulphide was formed from sulphur dioxide in the foliage, and this caused injury. Ziegler (1972) recently suggested that sulphur dioxide competes with carbon

dioxide for reaction sites and consequently interferes with photosynthesis. Wellburn (1972) has shown that sulphur dioxide causes swelling of the thylakoids within the chloroplasts and this damages them.

The harmful effects of air pollutants were separated by Guaderian (1960) into two distinct categories, 1) injury: the response of the plant 2) damage: the impairment of economic value. Knabe (1971) has established criteria by which harmful effects may be evaluated. In Tables 1 and 2 a modified form of this criteria is used to present the effects of sulphur dioxide on trees and forest communities that have been either reported in the literature or observed in the field by the author. These tables reflect a degradation in the condition or quality of the plants as they have deviated from their normal and do not express a comparison to a specific standard.

The phenomena which influence the effects of sulphur dioxide and other air pollutants on vegetation are summarized as follows:

1) The actual composition of the pollutant.

   A combination of gases can result in possible synergisms and predispositions or resistances.

2) The rate at which the pollutant reaches the receptor.

   This rate includes the concentration and quantity of the pollutants; and the interval and frequency at which the receptor is exposed.

3) The physical and physiological tolerance of the plant species to the pollutant as determined by genetic makeup.

4) The general vigor or health of the plant as a function of its ability to take stress.

5) The maturity and type of plant tissue the pollutant impinges on.

6) A wide variety of climatic conditions which strongly affect plant sensitivity both before and during exposure to the pollutant. These

factors include the qualitative and quantitative characters of light, temperature, wind, humidity and moisture. Loman et al (1972) provides a summary of conditions where tolerance levels are low.

7) Edaphic qualities such as soil moisture, acidity and nutritional availability.

In conclusion "conditions that favour good plant growth increase the capacity of the plant to assimilate sulphur dioxide, but reduce the plant's tolerance to this gas" (Loman et al 1972).

The Canadian Petroleum Association Submission makes reference to numerous studies which have been conducted on the variation in sensitivity of plants to sulphur dioxide gas. In each of these studies, only a few of the factors which affect sensitivity were chosen and tested as variables, with the other factors treated as constants. Examining the results of these studies out of context with the other variable factors results in an extremely attenuated picture regarding plant sensitivity rating, and some of the data presented in the submission strongly reflect this (e.g. Table 11 - 2 and Table 11 - 3).

The Submission contains reference to the sulphur dioxide sensitivity of the higher plants only, and disregards lower plants in the lichen and bryophyte groups which occur in abundance in all of Alberta's forest communities. These lower plant groups are much more sensitive to sulphur dioxide, with the lichens known to be damaged or eliminated from areas in England where constant annual concentrations of sulphur dioxide are around .02 ppm. (Mansfield and Bull 1972). Leblanc (1971) gives the following reasons for the lichen sensitivity to sulphur dioxide: 1) a high non selective capacity for accumulating substances from the atmosphere. 2) a low potential for

recovery after fumigation because of limited metabolic rates due to low chlorophyll content. 3) perennial evergreen habit. 4) lack of devices to close off gas transfer (the higher plants have specialized structures such as stomata which perform this task).

The sulphur dioxide concentration limits that are suggested in the Submission for Alberta are open to question. The evidence presented shows that damage does occur to Alberta plant species under the concentration limit recommended in the Submission. Dreisinger and McGovern's data from Sudbury, Ontario shown in Table 11 - 4 shows that damage did occur under .75 ppm. for 1 hr., during undefined environmental conditions to the following forest species which are native to Alberta: trembling aspen, jack pine, large toothed aspen, white birch, larch, willow and alder; and the following Alberta crop species: barley (missing from the table but included in Dreisinger and McGovern's 1970 presentation of the paper), oats, red clover, peas, rhubarb, timothy, lettuce, radish, squash, tomatoes, potatoes and raspberry. Wheat is not on the list of vegetation that Dreisinger and McGovern observed, but others have reported that it is a relatively sensitive species (e.g. Table 11 - 3 of the Submission lists it as such).

The environmental factors which control the susceptability of vegetation to sulphur dioxide were not reported in the evidence used in the Submission . Extrapolation of the "safe ground level concentrations and durations" from the data presented in the Submission to Alberta can be seriously questioned on this basis.

TABLE 1

INJURY CAUSED BY SULPHUR DIOXIDE AIR POLLUTION TO TREES AND FOREST COMMUNITIES

Criteria of effect	subject of investigation				
	part of a plant	individual plant	number of individuals	population (stand)	ecosyst
changes in cell components:	x	x	x	Na	Na
changes in metabolism	x	x	x	Na	Na
changes in cell structure	x	x	x	Na	Na
degree of foliar chlorosis or necrosis	x	x	x	Na	Na
premature foliar dropage	x	x	x	Na	Na
inhibited foliar growth	x	x	x	Na	Na
inhibited terminal growth	x	x	x	Na	Na
inhibited increment growth	x	x	x	Na	Na
predisposition to other stresses	x	x	x	Na	Na
plant death(s)	Na	x	x	Na	Na
percentage of plants injured to a certain degree	Na	Na	x	x	x
percentage of dead plants	Na	Na	x	x	x
decreased production of organic matter or decreased increment per area	Na	Na	Na	x	x
changes in number of species	Na	Na	Na	x	x
changes in abundance	Na	Na	Na	x	x
changes in coverage	Na	Na	Na	x	x
changes in general health conditions	Na	Na	x	x	x

x = detrimental changes have occurred

– = no changes have occurred

Na = not applicable to the category

TABLE 2

DAMAGE CAUSED BY SULPHUR DIOXIDE AIR POLLUTION TO TREES AND FOREST COMMUNITIES

airment in economic value	Subject of investigation				
Trees	part of a plant	individual plant	number of individuals	population (stand)	ecosystem
reduced fiber yields					
wood fiber formed before pollutant release	Na	–	–	–	Na
wood fiber formed during pollutant release	Na	x	x	x	Na
reduced quality of foliage					
elterbelts, ornamentals d Xmas trees)	x	x	x	x	Na
decreased resistance to biotic d abiotic influences (e.g. rk beetles, frost)	x	x	x	x	x
Forest communities					
increase of forest pests	Na	Na	Na	x	x
reduced recreational value	Na	Na	Na	x	x
reduced watershed value	Na	Na	Na	x	x
reduced wildlife habitat	Na	Na	Na	x	x
alterations in forest fluences (e.g. filter capacity)	Na	Na	x	x	x
airment in ideal value	x	x	x	x	x

x = detrimental changes have occurred

– = no changes have occurred

Na = not applicable to the category

LITERATURE CITED

Anonymous. 1968. Plants absorb sulfur dioxide release hydrogen sulfide. Sulfur Inst. J. 4: 17.

Dreisinger, B.R. and P.C. McGovern. 1970. Monitoring atmospheric sulfur dioxide and correlating its effects on crops and forests in the Sudbury area. Proc. Impact of Air Pollution on Vegetation Conference, Toronto: Pp. 23.

Dorries, W. 1932. Uber die Brauchbarkeit der spectroscopischen Phaophytinprobe in der Rauchschaden-Diagnostik. Z. Pflanzenkrankh. u. Gallenkunde 42: 257-273.

Guderian, Robert, H. Van Haut, H. Stratmann. 1960. Problems of the recognition and evaluation of the effects of gaseous air impurities on vegetation. Z. Pflanzenkr. Pflanzenpathol. Pflanzenschutz. 67 (5)257-264.

Haselhof, E. and G. Lindau. 1903. Die beschadigung der vegetation durch rauch. Gebruder Borntraeger. Leipzig. 412 p.

Knabe, Wilhelm. 1971. Air quality criteria and their importance for forests In: Proceedings of the XV Congress of IUFRO, Working Group "Fume damage" Sect. 24, pp 129-150.

Leblanc, Fabius 1971. Biological Methods for Mapping Atmospheric Pollution. In: Proceedings of the XV Congress of IUFRO, Working Group "Fume damage" Sect. 24 pp 104-126.

Loman, A.A., R.A. Blauel and D. Hocking. 1972. Sulphur dioxide and Forest Vegetation. Info. Rept. NOR-X-49. Nor. For. Res. Centre.

Mansfield, T.A. and J.N. Bull. 1972. The effects of SO_2 Pollution on Plant Life. In: The Environment This Month, Aug. Issue, Lancaster, England.

Nikolaevsky, V.S. 1968. Activity of certain enzymes and the gas resistance of woody plants. Trud. Inst. Ekol. Rast. Zivot. Ural sky Fil. ANSSSR 62: 208-211.

NOVAK, K. 1929. Damage to vegetation from gases in smoke. Z. Angew. Chem. 42: 123-126.

Thomas, M.D. 1951. Gas damage to plants. Ann. Rev. Plant Physiol. 2: 293-322.

Wellburn, A.R., O. Majernik and F.A.M. Wellburn (1972): Effects of SO_2 and NO_2 polluted air upon the ultrastructure of chloroplasts. Environmental Pollution 3: 37-49.

Ziegler, I. (1972): The effect of SO_3^{--} on the activity of ribulose-1, 5-diphosphate carboxylase in isolated spinach chloroplasts. Planta (Berlin) 103: 155-163.

C. R. GILBERT
COMMISSIONER

JOHN H. HALLS
COMMISSIONER

R. D. ROSS, C.A., F.C.I.S.
EXECUTIVE DIRECTOR AND SECRETARY

THE WORKMEN'S COMPENSATION BOARD
ALBERTA

9912 - 107 STREET
P.O. BOX 2415
EDMONTON

October 24, 1972.

Dr. W. R. Trost,
Chairman,
Environment Conservation Authority,
8th Floor,
9912 - 107 Street,
Edmonton, Alberta.

Dear Dr. Trost:

The Board has noted with interest and some concern the report in the October 20, 1972 edition of the Edmonton Journal that Mr. Harry Kostiuk, Assistant Executive Secretary of the Alberta Federation of Labour, submitted an AFL brief to the recent hearing held by the Environment Conservation Authority and that under questioning he said, "the Workmen's Compensation Board is reluctant to provide detailed files on the problem because it says the oil companies are very touchy about any publication of any instances that may happen in their plants."

In order to remove any possible misunderstanding in this respect I should point out that subsections (11) and (14) of Section 74 of The Workmen's Compensation Act provide as follows:

"(11) No member or officer of the Board and no person authorized to make an examination or inquiry under this Act shall divulge or allow to be divulged, except in the performance of his duties or under authority of the Board, any information obtained by him or that has come to his knowledge in making or in connection with an examination or inquiry under this Act."

"(14) No member or officer or employee of the Board shall divulge information respecting the business of an employer or a workman obtained by him in his capacity as such member or officer or employee unless it is divulged under the authority of the Board to the persons directly concerned or to agencies or departments of the Government of Canada or of the Government of any province."

I am sure you will readily see that pursuant to these provisions the Board would be unable to provide information concerning any specific employer and that this has nothing to do with the feelings of oil companies regarding this matter.

Yours very truly,

R. D. Ross,
Executive Director.

RDR:ak

APPENDICES

OCTOBER, 1972

ENVIRONMENT CONSERVATION
AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

TERMS OF REFERENCE FOR PUBLIC HEARINGS

ENVIRONMENTAL EFFECTS OF THE OPERATION OF

SULPHUR EXTRACTION GAS PLANTS

PINCHER CREEK	–	OCTOBER 2, 1972
RED DEER	–	OCTOBER 5, 1972
WHITECOURT	–	OCTOBER 11, 1972
CALGARY	–	OCTOBER 16, 1972
EDMONTON	–	OCTOBER 19, 1972

ENVIRONMENT CONSERVATION AUTHORITY

JUNE, 1972

ENVIRONMENTAL EFFECTS

The effects on the environment of operating sulphur extraction gas plants in Alberta include all effects on materials and on living processes, including beneficial effects, of all developments and manifestations leading to the production of the gas, its treatment and the transportation to and consumption of all products by a customer.

MAJOR CHEMICAL CONSTITUENTS

The major chemical constituents with which concern is associated are elemental sulphur and gaseous sulphur dioxide, hydrogen sulphide and sulphur-containing hydrocarbons released to the environment at any stage in the extraction process.

PLANT OPERATIONS

It is permissive that all aspects of sulphur extraction operations bearing on the environment will be discussed at the hearings. This will include the effect of well drilling, pipeline corosion, transmission lines and plant location on the environment, as well as in-plant health and hazard phenomena, but only to the extent that they depend on or are affected by sulphur-bearing materials. Emphasis is to be placed on the operation of the plants themselves, on the processes by which the sulphur-bearing materials are treated and the products gathered, recycled and finally released. Laws and regulations affecting plant operation, particularly those related to pollution control are also to receive consideration.

SULPHUR

Elemental sulphur that is produced, gathered, stock-piled and shipped may have an effect on the surroundings during any of these stages. It is hoped that these effects, how they relate to the elemental sulphur and how protection will be provided, will be discussed.

SULPHUR COMPOUNDS

The effects of compounds released by extraction plants on the health of humans or animals as well as the chemical effects on vegetation is of significance and will receive attention. Of particular importance is the establishment of the cause and effect relationship that may exist when damage is attributed to plant effluents.

SIDE EFFECTS

Side effects of other aspects of the overall process may also need investigation or be involved in the hearings. Examples of these are the side effects of the compressor plants, including the noise problem on the one hand and the leakage of the high temperature oil, triaryl phosphate, with its possible damage to animals on the other. The effect of meteorological conditions on dispersal of stack or flare gases, the release of chemicals used within the plants and the treatment of waste products from the operation may also be considered. Emphasis is to be placed, however, on those aspects that depend upon sulphur content.

OBJECTIVE OF THE HEARINGS

Through public hearings to enquire into all effects on the environment of the operation of sulphur extraction gas plants in Alberta, and to review all legislation pertaining thereto; and to lay the views presented to the Authority and the Authority's recommendations thereon before the Lieutenant Governor-in-Council through the Minister of the Environment.

DR. W. R. TROST, Chairman,
Environment Conservation Authority.

A PROSPECTUS FOR PUBLIC HEARINGS

ENVIRONMENTAL EFFECTS OF THE OPERATION OF

SULPHUR EXTRACTION GAS PLANTS

PINCHER CREEK	–	OCTOBER 2, 1972
RED DEER	–	OCTOBER 5, 1972
WHITECOURT	–	OCTOBER 11, 1972
CALGARY	–	OCTOBER 16, 1972
EDMONTON	–	OCTOBER 19, 1972

ENVIRONMENT CONSERVATION AUTHORITY

JUNE, 1972

ENVIRONMENT CONSERVATION AUTHORITY
PROSPECTUS ON

THE ENVIRONMENTAL EFFECTS OF
THE OPERATION OF
SULPHUR EXTRACTION GAS PLANTS IN ALBERTA

INTRODUCTION

Alberta possesses reserves of energy fuels in more than one form. It has the good fortune that its coals, whether in the mountains or in the prairies, are relatively low in sulphur content.

This is an important advantage to the province in marketing both its coking and thermal coals, for in each of these applications sulphur would be a costly impurity. In addition the environmental effects of sulphur associated with coal, such as the acid effluents so well known in eastern coalfields, are not present here.

By contrast, however, a considerable proportion of the deposits of natural gas in the province do contain sulphur, sometimes in high percentages. The sulphurous compounds in natural gas are costly impurities and must be removed before the natural gas can be marketed. They also can present serious environmental hazards by nature of their toxicity and because of the unpleasant odors associated with them.

The Petroleum Gas Industry in Alberta has had many years of experience in the handling of sour gasses. During this time it has achieved significant improvements in gas processing technology and in handling the problems that sulfurous gasses have presented in the preparation of its products for the market.

During the same period the government introduced regulations which have also changed over the years and has developed and adopted methods for monitoring the compliance of the operating plants with these regulations.

The sour gas fields and the sulphur extraction plants are located in many areas of the province and large numbers of people have been exposed for many years to the operations of these plants. A number of claims and complaints concerning human and animal health, or damage and destruction

to crops and property have been made by persons living in the vicinity of operating gas plants, it has not always been possible to clearly establish the cause/effect relationships in cases like these.

The Environment Conservation Authority has now been requested by the Honourable W. J. Yurko, Minister of the Environment, to hold public hearings on the environmental effects of the operation of sulphur extraction gas plants in Alberta. The hearings are to take place during October, 1972, in Pincher Creek, Red Deer, Whitecourt, Calgary and Edmonton. The Authority will then submit to the government recommendations based on the information presented at the hearings.

SULPHUR EXTRACTION IN ALBERTA

Several natural gas fields in Alberta have been found to contain sulphur in substantial quantities, the highest being in one field where the content of sulphur in the form of hydrogen sulphide accounts for 90% of the total volume of the gas. The maximum concentration of hydrogen sulphide in natural gas which is processed at present, however, is 50%. If a natural gas must be processed to remove hydrogen sulphide before it can be marketed, it is known as a "sour" or "acid" gas, whereas if the concentration of hydrogen sulphide in the gas as it comes from the well is low enough to require no special processing, it is called a "sweet" or "sales" gas.

In the early 1950's natural gas came into considerable demand as a source of energy and with improved technology it became economic to build processing plants to produce "sales" gas from sour gas fields. The hydrogen sulphide that was removed in the sweetening process was converted into elemental sulphur, itself a marketable commodity, and Alberta soon became a large producer of sulphur. By 1971, there were forty-two sulphur extraction plants in operation in Alberta and they were producing a total of 4.5 million long tons of elemental sulphur per annum.

The supply of sulphur however, has in the past several years exceeded the demand, due mainly to the huge quantities produced in Alberta, and as a result the price of sulphur has fallen from a high of $35.53 per ton in 1968 to the present level of about $7.50 per ton f.o.b. Alberta.

The excess sulphur which cannot be sold must be stored and by the end of 1971 the total stockpile in Alberta had grown to 5.3 million tons. It is estimated that the remaining established reserves of sour natural gas in Alberta contain about 180 million long tons of sulphur and that most of this will be recovered within the next twenty to thirty years. The supply of sulphur can therefore be expected to continue to increase and unless new markets are found for elemental sulphur, the Alberta stockpile will also continue to grow.

HISTORY OF SULPHUR RELATED EMISSIONS

In the early days of the natural gas industry the comparatively small quantities of hydrogen sulphide which had to be removed from sour gases were burned in special furnaces to convert the hydrogen sulfide into sulphur dioxide. Sulphur dioxide is a less toxic and less odorous gas at low concentrations and all that was produced was allowed to go into the air through tall stacks. As the industry developed and sour gases containing greater quantitites of hydrogen sulphide came to be processed, this method of handling the hydrogen sulphide was found to be no longer adequate because of the excessive quantities of sulphur dioxide that would have to be liberated into the atmosphere. The industry also realized at this time, that a marketable product could be obtained if the hydrogen sulphide was not vented as sulphur dioxide but was instead converted into elemental sulphur. In 1951 the first sulphur extraction gas processing plant in Alberta was built at Jumping Pound. Although the gaseous compounds released to the atmosphere from a gas processing plant, which are of major concern, are hydrogen sulphide and sulphur dioxide, there may also be other compounds of sulphur or other toxic chemicals released in small quantities. The efforts of both government and industry are now being directed towards the identification and measurement of these emissions as well, and standards are being developed for their control.

Today, whenever hydrogen sulphide is recovered in any appreciable quantity the sulphur is extracted in elemental form. Since the percentage of hydrogen sulphide in the sour gas varies from field to field, however, not all processing plants in Alberta have sulphur extraction facilities. Out of a total of sixty-seven plants processing sour gas in 1971, forty-two

were equipped to recover solid sulphur, while the remainder vented all sulphur as sulphur dioxide. Even in those plants which recover solid sulphur the sulphur extraction operation is not 100% efficient and that part of the hydrogen sulphide which is not converted into elemental sulphur by the process still has to be burned and vented into the air as sulphur dioxide. As a result, the total emission of sulphur as sulphur dioxide from all sour gas processing plants in the province in 1971 was over 450 long tons per day.

In the interest of environmental protection as well as the conservation of the sulphur resource the gas industry will be required within the next two years to recover a higher percentage of sulphur from the hydrogen sulphide in its gas. While this measure will reduce the total sulphur dioxide emissions for a period of time, the possibility still exists that the total quantities released to the atmosphere will eventually exceed those of today if sour gas production increases sufficiently.

LEGISLATION and REGULATIONS

The presence of hydrogen sulphide in a large portion of Alberta's natural gas deposits has made it necessary for the government to pass legislation for the control of gas processing plant operations and this has been reflected in a number of regulations which the industry must follow in order to meet the standards set forth in the legislation. Two government agencies share the responsibility for ensuring that the industry complies with the legislation: the Department of the Environment by monitoring off site pollution levels, and the Energy Resources Conservation Board by concerning itself with on-site operations.

Of considerable importance are the ambient air quality standards that have been drawn up for Alberta. These standards, which prescribe the maximum permissible concentration of the more important established pollutants in the atmosphere, have been set by the government for the protection of the health and welfare of all citizens. Sulphur extraction gas plants must ensure that their emissions to the surrounding atmosphere do not result in pollutant levels which exceed the standards.

According to the Alberta Ambient Air Quality Standards, the acceptable levels for sulphur dioxide in the air are 0.2 part per million or 0.00002% averaged over a 30 minute period in an urban or agricultural area, or 0.3 part

per million over a 24 hour period in all areas. The average concentration allowed for hydrogen sulphide is 0.03 part per million for a one hour period and 0.005 part per million over a 24 hour period.

Although these allowable pollutant levels have been set as a protection for citizens and to prevent insofar as possible any deleterious effects to animals, plants and property, a lot remains to be determined about the long-term effects of very low concentrations of these gases in the atmosphere. As these effects become better understood it may be that the standards will have to be revised.

ENVIRONMENTAL EFFECTS

Any plant processing sour natural gas may from time to time become the source of unpleasant odours. One of these odors which has often been likened to the smell of rotten eggs can be caused by trace amounts of hydrogen sulphide in the air. Although this odor, when it occurs, is usually predominant, odors due to sulphur dioxide and other chemicals may also be detected in some cases.

Because of the sensitivity of the human nose, odorous chemical substances can often be detected in extremely small quantities. The smallest concentration at which the human nose is able to detect the presence of a chemical substance is referred to as its threshold odor level. It varies not only from substance to substance, but also with different individuals and their physical state at the time. A good approximation of the threshold odor level is the concentration of the chemical at which one half of the number of persons of any group of normally healthy people will just detect the odor.

In the setting of ambient air quality standards, the absence of any detectable odor is usually one of the criteria on which the limits are based since even where no direct physical harm results, discomfort and even secondary physical effects may result from the presence of unpleasant odors. This can be particularly important in the case of the aged or those with respiratory or serious emotional problems.

In the case of hydrogen sulphide, odors may be detected in concentrations as low as 0.03 part per million whereas for sulphur dioxide, the detection level is 0.3 part per million and at this level appears to be a "taste" rather than a smell sensation. A noticeable pungent odor of sulphur dioxide

appears to require a concentration of 3 parts per million or one hundred times the level at which hydrogen sulphide can be detected by odor.

As far as is known, exposure for short periods of time to the minimum detection levels of these substances does not produce harmful effects.

Other environmental effects can be associated with blowouts at a wellhead or the rupture of a transmission line or plant equipment. In either case large quantities of hydrogen sulphide might escape and the resulting concentrations in the air can cause serious damage. Sulphur dust blowing into the air from sulphur storage piles has, in some cases, been cited as contributing to an increase in soil acidity and thereby endangering crop production. On the other hand, it is also said that if sulphur dust is added to an alkaline soil the resulting lowering of the alkalinity may actually enhance crop production. Contamination of ground water or streams by runoff from effluent ponds attached to gas plants, must also be considered a possible hazard.

Although the emphasis of the present study is focused on the obvious chemical compounds, such as hydrogen sulphide, sulphur dioxide and elemental sulphur, there are other substances which may be the cause of environmental damage, and attention should be directed to these as well. Examples of these are traces of Mercaptans and other compounds or elements which may be present in the sour gas, Carbonyl Sulphide and Carbon Disulphide which may be formed during the sulphur extraction operation, and various spent chemicals from general plant operations. Of particular importance is the establishment of the presence of these materials in the waste gases leaving the gas plants and the effects that can be attributed to them in the concentrations in which they then occur in the air surrounding the plant.

THE PUBLIC HEARINGS

During the hearings on the environmental effects of sulphur extraction gas plants an opportunity will be afforded for all concerned to express their views on this important subject. Briefs will be invited from individual citizens, cities, towns, labour and farm organizations, members of the academic community, women's groups, environmental groups, industry representatives, school groups and any other groups which might wish to present information on the subject.

At the request of the Environment Conservation Authority the Research Council of Alberta provided the services of a consultant to prepare a situation report on the environmental effects of sulphur extraction gas plants. This report is a public document, available at the offices of the Authority. It is intended to present an overview of the subject and provide a basis for discussion, and the Authority does not necessarily agree or disagree with anything contained in it. Topics discussed in this report include: the magnitude of the sulphur industry; extraction plant operation; plant effluents; meteorological dispersal of gaseous pollutants particularly sulphur dioxide, the effects on humans, animals and vegetation of various pollutants and what is known about them, and pollution control legislation affecting the sulphur extraction plants.

Participants at the hearings are encouraged to present briefs on any environmental aspect connected with the production, transportation and processing of sour gas and the storage, handling and transportation of the products to their markets.

It is expected that attention will be directed to such specifics as:

1. long and short range effects on the health of humans and animals;
2. effects on vegetation;
3. effects on inanimate property;
4. case histories of alleged effects of sulphurous gases on human plant or animal health or the safety of property.
5. environmental protection methods employed by the industry;
6. environmental effects inside the plant;
7. legislation, regulations, and standards;
8. monitoring systems and methods of measurement;
9. odors and their effects on humans and animals;
10. the need for research;
11. the role of government and industry in environmental protection.

The Authority hopes that some briefs will be able to provide first hand or specialized information on particular aspects of the subject about which general knowledge is deficient, or where misconceptions might be considered to exist. Factual information or data on cause/effect relationships connected with the operation of gas plants and their transmission lines, would be of particular interest.

All interested groups and individuals, and the general public are encouraged to attend the hearings and make their views known. On completion of the hearings reports will be made to the public in three ways. Firstly, all briefs presented to the hearings as well as all ensuing discussions will be recorded, assembled as the "Proceedings" of the Hearings, and published in book form by the Authority at nominal cost. Secondly, a "Summary" of the Hearings will be produced, also in book form, for free distribution on request.

Finally the Authority will develop its "Report and Recommendations" for submission to the Minister of the Environment and the Legislative Council. This report will also become freely available to the public as soon as it is tabled by the Minister in the House.

LIST OF PUBLICATIONS

OCTOBER, 1972

The following publications prepared by or on behalf of the Authority are available on request while they remain in stock.

In some cases a charge will be made.

Requests should be addressed to

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107th Street, Edmonton, Alberta T5K 1G5
Telephone (403) 423-2247

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

LIST OF PUBLICATIONS

ENVIRONMENT CONSERVATION AUTHORITY. Brochure. Revised Edition. 1972.

ENVIRONMENT CONSERVATION ACT, 1970. Office Compilation. Chapter 36 of the Statutes of Alberta, 1970, with Amendments up to June 2, 1972, and pertinent sections of other Acts referring to the Environment Conservation Authority. 10 pages.

ANNUAL REPORTS

ENVIRONMENT CONSERVATION AUTHORITY. First Annual Report, November 1970 to November 1971. April, 1972. 101 pages.

PUBLICATIONS ON PUBLIC HEARINGS

1. PUBLIC HEARINGS ON A PROPOSAL TO RESTORE WATER LEVELS IN COOKING AND HASTINGS LAKES, AUGUST 23, 25, 1971.

AN ECONOMIC ANALYSIS OF THE COOKING AND HASTINGS LAKES. E.P.E.C. Consulting Ltd. June 10, 1971.

RECREATION POTENTIAL AND DEVELOPMENT FEASIBILITY IN HALFMOON, HASTINGS AND COOKING LAKES. Macroplan Consultants Ltd. July - August, 1971.

ALTERNATE LAND USE EVALUATION. Acres Western Limited, August, 1971. 27 pages.

PUBLIC HEARINGS ON A PROPOSAL TO RESTORE WATER LEVELS IN COOKING AND HASTINGS LAKES. Prospectus. 1971. 8 pages.

PUBLIC HEARINGS ON A PROPOSAL TO RESTORE WATER LEVELS IN COOKING AND HASTINGS LAKES. Proceedings. August, 1971. 1 v. 230 pages.

PUBLIC HEARINGS ON A PROPOSAL TO RESTORE WATER LEVELS IN COOKING AND HASTINGS LAKES. Summary. August, 1971. 64 pages.

PUBLIC HEARINGS ON A PROPOSAL TO RESTORE WATER LEVELS IN COOKING AND HASTINGS LAKES. Report and Recommendations. August, 1971. 41 pages.

2. PUBLIC HEARINGS ON THE ENVIRONMENTAL IMPACT OF SURFACE MINING IN ALBERTA

DECEMBER 13, 15, 17, 21, 1971 and JANUARY 6, 1972

ENVIRONMENTAL IMPACT OF SURFACE COAL MINING OPERATIONS IN ALBERTA. F.F. Slaney and Co. November, 1971. 59 pages. (Reproduced in Proceedings).

THE ENVIRONMENTAL IMPACT OF SURFACE MINING IN ALBERTA. A Prospectus for Public Hearings, 1971. 6 pages.

THE IMPACT ON THE ENVIRONMENT OF SURFACE MINING IN ALBERTA. Proceedings of the Public Hearings, December, 1971, January, 1972. 2 v. 1060 pages. $4.00

THE IMPACT ON THE ENVIRONMENT OF SURFACE MINING IN ALBERTA. Summary of the Public Hearings, December, 1971, January, 1972. 205 pages.

THE IMPACT ON THE ENVIRONMENT OF SURFACE MINING IN ALBERTA. Report and Recommendations. December, 1971, January, 1972. 99 pages.

3. PUBLIC HEARINGS ON THE CONSERVATION OF ARCHAEOLOGICAL AND HISTORICAL RESOURCES IN ALBERTA

May 25, 29, June 1, 1972

THE CONSERVATION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES IN ALBERTA. A Prospectus for Public Hearings. 7 pages.

THE CONSERVATION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES IN ALBERTA. Position paper for Public Hearings prepared by the Public Advisory Committee on the Conservation of Historical and Archaeological Resources, March, 1972. 8 pages. (Includes three-page Addendum).

THE CONSERVATION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES IN ALBERTA. Report prepared by the Public Advisory Committee on the Conservation of Historical and Archaeological Resources. March, 1972. 32 pages.

THE CONSERVATION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES IN ALBERTA. Proceedings of the Public Hearings. May 25, 29 and June 1, 1972. 1 v. 565 pages. $3.00

THE CONSERVATION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES IN ALBERTA. Summary of the Public Hearings. May 25, 29 and June 1, 1972.

* THE CONSERVATION OF HISTORICAL AND ARCHAEOLOGICAL RESOURCES IN ALBERTA. Report and Recommendations. May 25, 29 and June 1, 1972.

4. PUBLIC HEARINGS ON THE ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS

October 2, 5, 11, 16, 19, 1972

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS. Dr. R.K. Klemm, August, 1972. 116 pages.

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS. Terms of Reference for Public Hearings, June, 1972. 2 pages.

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS. A Prospectus for Public Hearings, October 2, 5, 11, 16 and 19, 1972. 8 pages.

ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS. Proceedings of the Public Hearings, October 2, 5, 11, 16 and 19, 1972.

* ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS. Summary of the Public Hearings, October 2, 5, 11, 16 and 19, 1972.

* ENVIRONMENTAL EFFECTS OF THE OPERATION OF SULPHUR EXTRACTION GAS PLANTS. Report and Recommendations.

SPECIAL REPORTS

FIRST ANNUAL REPORT OF THE PUBLIC ADVISORY COMMITTEE. 1971. 125 pages.

* SECOND ANNUAL REPORT OF THE PUBLIC ADVISORY COMMITTEE. 1972.

ADDITIONAL STUDIES AVAILABLE

THE FOREST RESOURCE IN ALBERTA. E.P.E.C. Consulting Ltd. June 1972. By Special Order.

* THE ENVIRONMENTAL IMPACT OF FOREST UTILIZATION IN ALBERTA.
W.R. Hanson.

FOUR WAYS FORWARD - ENVIRONMENT CONSERVATION AUTHORITY. October, 1972.

A PRELIMINARY ASSESSMENT OF ENVIRONMENTAL IMPACT OF OIL AND GAS EXPLORATION AND PIPELINE OPERATIONS IN ALBERTA. Underwood, McLellan and Associates Ltd. June, 1972. 51 pages. By Special Order.

* Being compiled at the time of this publication.

INDEX

OCTOBER, 1972

ENVIRONMENT CONSERVATION AUTHORITY
9912 - 107 Street
Edmonton, Alberta
T5K 1G5

INDEX